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THE DOCTRINE OF EVOLUTION: ITS SCOPE AND INFLUENCE.*

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IF you take up almost any manual or compendium of history written before the middle of the present century, you will generally find it to be a lifeless catalogue of events, and more likely than not an undiscriminating catalogue in which important and trivial events are jumbled together in utter obliviousness of any such thing as historical perspective. Of great and admirable books of history there were indeed many by illustrious writers of ancient and modern times, in which the men, the measures, and the social features of particular epochs were portrayed with life-like reality and often illustrated and criticised with a wealth of practical wisdom. But the insight into the underlying causes and the general drift of the endlessly complicated mass of human affairs was dim and uncertain, and of the essential unity of history, the solidarity in the multifarious career of mankind, there was hardly a suspicion. Three great books in narrative form, which reached out toward a presentation of the unity of history, may be cited in illustration of the difficulty under which all such attempts necessarily labored in the absence of such broad scientific conceptions as have been gained only within recent times. Bossuet's Discourse on Universal History was a work of noble design; but, being necessarily limited by the narrow theology of the time, it could only see the vast importance of the work of the Hebrew race, and, seeing no further, could not properly estimate even this; while as for any appreciation of natural causes, its perpetual appeal to the miraculous made anything of the sort quite impossible. In Voltaire's Essay on the Manners and Morals of Nations there

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is a strong foreshadowing of the unity of history, but very slight practical recognition of the differences between one stage of civilization and another, and the philosophy of the book is quite too much that of a sermon on the evils of priestcraft. In the colossal work of Gibbon there is a dramatic unity of design and a sense of historical perspective that from an artistic point of view can not be praised too highly. It is, no doubt, an immortal book, one of the classics for all ages; but as an interpretation of events it goes but little way. The period of twelve hundred years which it covers was crowded with facts of decisive import for all future time which failed to arrest the author's attention. There is no consciousness that this period, which witnessed the decline and overthrow of a certain phase of political organization, was in the main a period of lusty growth and wholesome progress rather than a period of stagnation or decline. Nor, indeed, is there any explanation of the great conspicuous fact of the decline and fall of the Roman imperial organization; we are told *what* events happened, and often *how* they happened, but we are seldom made to understand *why* they happened. The grasp upon the underlying causes is extremely feeble, as one can not but feel in a moment if, after laying down Gibbon, one picks up a volume of Mommsen, or Freeman, or Sir Henry Maine.

Most of the shortcomings of the old method of historical writing resulted from the fact that the world was looked at from a statical point of view, or as if a picture of the world were a series of detached pictures of things at rest. The human race and its terrestrial habitat were tacitly assumed to have been always very much the same as at present. One age was treated much like another, and when comparisons were made it was after a manner as different from the modern comparative method as alchemy was different from chemistry. As men's studies had not yet been turned in such a direction as to enable them to appreciate the immensity of the results that are wrought by the cumulative action of minute causes, they were disposed to attach too much importance to the catastrophic and marvelous; and the agency of powerful individuals—which upon any sound theory must be regarded as of great importance—they not only magnified unduly but rendered it unintelligible when they sought to transform human heroes into demi-gods.

It thus appears that the way in which our forefathers treated history was part and parcel of the way in which they regarded the world. Whether in history or in the physical sciences, they found themselves confronted by a seemingly chaotic mass of facts with which they could deal only in a vague and groping manner and in small detached groups. Until geology had made some headway, men had no means of knowing that the state of

things upon the earth's surface was once utterly different from anything that human tradition can remember, and it was accordingly quite natural that they should suppose that things have always been about as they are. The human mind can not transcend experience. The man who has always lived in a comparatively unchanged environment will, of course, never believe in a different state of things until taught by some fresh experience. How long it was before it was brought home to men that the testimony of the unaided senses needs to be corrected by systematic observation and reasoning! From this point of view, as indeed from some others also, the revolution in astronomical theory effected by Copernicus was one of the greatest events in human history. Its philosophic consequences were profound. In teaching men the necessity of going back of superficial appearances, and subjecting their crude opinions to some kind of critical test, it was an object-lesson of unsurpassed value. Along with this abrupt shifting of man's apparent position in the universe, came the astonishing results of oceanic discovery, enlarging fourfold the dimensions of the known world and bringing the mind into contact with organic and inorganic nature in various new and unsuspected forms. Then came the Newtonian astronomy, in which a generalization from terrestrial physics was extended into the celestial spaces and quantitatively verified. There was an immense enlargement of the mental horizon, and the problems immediately connected with it were enough to occupy the attention of all the foremost mathematical minds for more than a century. It made man a denizen of the solar system as well as of his own particular planet; and in these latter days, since the law of gravitation has been extended to the sidereal heavens and spectrum analysis has begun to deal with nebulæ, there is abundant proof that properties of matter and processes with which we are familiar on this earth are to be found in some of the remotest bodies which the telescope can reach, and it is thus forcibly impressed upon us that all are parts of one stupendous whole.

This enlargement of the mental horizon, from Newton to Kirchhoff, had reference to space. A similar enlargement with reference to time was an indispensable preliminary to any correct understanding of how the world is made and what is going on in it. But, before much headway could be made in geology, it was necessary that physics and chemistry, the sciences which generalize the properties of matter, in the mass and in the molecule, should be to some extent apprehended; and it is almost startling to think how modern all this is—scarcely more than a hundred years since Priestley discovered oxygen, since it became possible to tell what goes on when you burn a log of wood on the hearth! and not so very much longer since Black discovered latent heat and gave us

a clew to what happens when water freezes and melts or when it is turned into steam! It is only within fifty years that physics and chemistry have begun to assume the form of coherent bodies of scientific truth. Evidently geology could not be expected to take scientific shape until late in the eighteenth century, or to make any notable conquests before the nineteenth. But when geology did win its first great triumph, about sixty years ago, it was in some ways the most remarkable moment in the history of thought since the promulgation of the Newtonian astronomy. Newton proved that the forces which keep the planets in their orbits are not strange or supernatural forces, but just such forces as we are familiar with on this earth every moment of our lives. Geologists before Lyell had been led to the conclusion that the general aspect of the earth's surface with which we are familiar is by no means its primitive or its permanent aspect, but that there has been a succession of ages in which the relations of land and water, of mountain and plain have varied to a very considerable extent, in which soils and climates have undergone most complicated vicissitudes, and in which the earth's vegetable products and its animal populations have again and again assumed new forms while the old forms have passed away. In order to account for such wholesale changes, geologists were at first disposed to imagine violent catastrophes brought about by strange agencies—agencies which were perhaps not exactly supernatural, but in some unspecified way different from the agencies that are now at work in the visible and familiar order of Nature. But Lyell proved that the very same kind of physical processes which are now going on about us would suffice during a long period of time to produce the changes in the inorganic world which distinguish one geological period from another. Here, in Lyell's geological investigations, there was for the first time due attention paid to the immense importance of the prolonged and cumulative action of slight and unobtrusive causes. The continual dropping that wears away stones might have served as a text for the whole series of beautiful researches of which he first summed up the results in 1830. As astronomy was steadily advancing toward the proof that in the remotest abysses of space the physical forces at work are the same as terrestrial forces; so now geology, in carrying us back to enormously remote periods of time, began to teach that the forces at work have all along been the same forces that are at work now. In that early stage when the earth's crust was in process of formation, when the temperature was excessively high, there were, of course, phenomena such as can not now be witnessed here, but to find a parallel to which we must look to certain other planets—such as violent atmospheric disturbances, and such as the dissociation of chemical elements which we are accustomed to find in

close combination. But since the cooling of the earth to a point at which its solid crust acquired stability, since the ancestors of the amphioxus began to swim in the seas and worms to crawl in the ground, if you could at almost any time have visited the earth, you would doubtless have found things going on at measured pace very much as at present—here and there earthquake and avalanche, fire and flood, but generally rain falling, sunshine quickening, herbage sprouting, creatures browsing, all as quiet and peaceful as a daisied field in June, without the slightest presage of the continuous series of secular changes that were gradually to transform the Carboniferous world into what was by and by to be a Jurassic world, and that again into what was after a while to be an Eocene world, and so on until the aspect of the world which we know should quietly emerge.

The influence of the new geology upon men's habits of thought and upon the drift of philosophic speculation was profound. It was proved beyond question that the world was not created in the form in which we find it to-day, but has gone through many phases of which the later are very different in aspect from the earlier; and it was shown that, at any rate so far as the inorganic world is concerned, its changes can be much more satisfactorily explained by a reference to the ceaseless, all-pervading activity of gentle, unobtrusive causes such as we know, than by an appeal to imaginary catastrophes such as we have no means of verifying. It began to appear, also, that the facts which form the subject-matter of different departments of science are not detached and independent groups of facts, but that all are intimately related one with another, and that all may be brought under contribution in illustrating the history of cosmical events. Thus, in one way and another, about the time when Mr. Darwin set out on his memorable voyage around the world, men were beginning to arrive at a vague general conception of evolution as an orderly succession of phases of nature, in which any given phase is produced from an antecedent phase through the agency of causes which are like those now in operation, and which must therefore admit of definite scientific study and explanation.

The time had at length arrived when the facts of organic life could be brought under this general conception. As long as it was supposed that each geologic period was separated from the periods immediately before and after it by Titanic convulsions which revolutionized the face of the globe, it was possible for men to acquiesce in the supposition that these convulsions wrought an abrupt and wholesale destruction of organic life, and that the lost forms were replaced by an equally abrupt and wholesale supernatural creation of new forms at the beginning of each new period. But as people ceased to believe in the convulsions, such

an explanation began to seem very improbable, and it was completely discredited by the fact that many kinds of plants and animals have persisted with little or no change during several successive periods, side by side with other kinds in which there has been extensive variation and extinction. It was further observed that between the forms of successive periods in the same geographical regions there was a manifest family likeness, indicating that the later were connected with the earlier through the ordinary bonds of physical descent. A host of facts from comparative morphology and embryology went to confirm this inference; and so, when after nearly twenty years of incubation Mr. Darwin was ready to plant the seeds of his remarkable theory, he found the soil very thoroughly prepared and fertilized in which to plant them. All that men were waiting for was the discovery of a *vera causa*, All that was wanted was to be able to point to some one agency. similar to agencies now in operation and therefore intelligible, which could be proved to be capable of making specific changes in plants and animals. Mr. Darwin's solution of the problem was so beautiful, it has become so generally accepted and so deeply interfused into all the thinking of our time, it seems now so natural and so inevitable, that we may be in danger of forgetting that the problem was really one of the most complicated and abstruse that the scientific mind has ever grappled with. Starting from the known experiences of breeders of domestic animals and cultivated plants, and duly considering the remarkable and sometimes wonderful changes that are wrought by the simple process of selection, the problem before Mr. Darwin was to detect among the multifarious phenomena of organic nature any agency capable of accomplishing what man thus accomplishes by selection. In detecting the agency of *natural selection*, working perpetually through the preservation of favored individuals and races in the struggle for existence, Mr. Darwin found the *vera causa* for which men were waiting. With infinite patience and caution he applied his method of explanation to one group of organic phenomena after another, meeting in every quarter with fresh and often unexpected verification. He had the satisfaction of living to see pretty much the whole contemporary world of zoölogists, botanists, and palæontologists pursuing the lines of investigation which he had laid down and in general agreement as to the fundamental principle. There was a general acquiescence in natural selection as an agency capable of working specific changes, while further speculation and investigation in all directions were employed in ascertaining the precise character of its work and determining the limits of its efficacy. That all the phenomena of the organic world can be accounted for by natural selection, Mr. Darwin never at any time supposed; nor was he ever so silly as to suppose that all

difficulties had been removed by himself or were likely to be removed within a single generation by the collective work of the whole scientific world. The present generation has witnessed a tendency toward restricting the probable limits of the efficacy of natural selection, followed by an equally marked tendency toward enlarging them—a tendency likely to be furthered by Mr. Wallace's recent book, pointing out the great extent of variation that normally goes on within the limits of one and the same species. Such minor fluctuations in scientific theory occur in all departments of inquiry, but no one doubts the essential soundness of the Darwinian theory, and as for the doctrine of special creations which it superseded, we shall probably go back to it when we go back to stone arrow-heads and the primitive Aryan ox-cart, and not before.

It has more than once been observed that, when a new discovery in science is announced to the world, people at first scout it as ridiculous or frown upon it as impious, but afterward, when it is no longer possible to gainsay it, they suddenly find that everybody knew all about it long ago. This habit is probably due to an exaggerated regard for consistency and a failure to realize that the thoughts of men are, and ought to be, widened with the progress of the suns. About the origin and history of the doctrine of evolution there is in the popular mind a great confusion of ideas; and this, as we now begin to see, is because the conception of evolution is itself something which has grown up gradually. It is an end toward which the whole momentum of scientific thought since Newton's day has been tending, yet which has been clearly and fully recognized only of late years. As regards Mr. Darwin's contribution to the general result, it admits of precise definition. The doctrine of natural selection, which Mr. Spencer afterward called "the survival of the fittest," belongs to Mr. Darwin and to Mr. Wallace as much as the differential calculus belongs to Newton and Leibnitz. The same problem was solved in the same way, first by Mr. Darwin, and then a dozen years later by Mr. Wallace in complete ignorance of what Mr. Darwin had done. "Darwinism" is the doctrine which maintains that many different forms of animal and vegetable life have a common ancestry, and which defines and describes natural selection as the chief agent in bringing about divergencies. Its distinctive feature—that which constitutes its value and its grandeur as a scientific doctrine—is the discovery and demonstration of the agency of natural selection. No one anticipated Mr. Darwin in that.

But the doctrine of natural selection is one thing, and the doctrine of evolution is quite another thing. It covers much more ground, and a good deal of it is ground with which Mr. Darwin had little or nothing to do. Vague notions of evolution were in

the air long before Darwin. When Emerson speaks of the worm mounting through the various spheres of form, we are sometimes told that in this and other similar remarks he anticipated Darwin. But such language is misleading. Great writers might have gone on until the present moment expressing a conviction that higher forms of life have been evolved from lower forms, but all that would have been of small avail as scientific doctrine until somebody could show how it has been done. The belief in an evolution of higher from lower organisms was held by a few eminent men of science for a great part of the century preceding Mr. Darwin's discovery. It is a belief that could not fail to be strongly suggested to minds of a certain philosophic cast as soon as the classification of plants and animals had begun to be conducted upon scientific principles. It is not for nothing that a table of classes, orders, families, genera, and species, when graphically laid out, resembles a family tree. It was not long after Linnæus that believers in some sort of a development theory, often fantastic enough, began to appear. Palæontology gave further suggestions in the same direction. When Cuvier brought palæontology into alliance with systematic zoölogy, and effected his grand classification of animals in space and time, he prepared the way most thoroughly for a theory of evolution, though he always resisted any such inference from his work. ⟨He builded better than he knew.⟩ A general belief in development, as opposed to special creations, was held by Mr. Darwin's distinguished grandfather in England, by Lamarck and Geoffroy Saint-Hilaire in France, and by Oken and Goethe in Germany. In the present age it was maintained in print by Herbert Spencer in 1852, before Darwin had published anything on the subject.

During the early part of the present century applications of the comparative method in various directions were rapidly educating the minds of the younger generation of students into a vague perception of development as something characteristic of all sorts of phenomena. The first two great triumphs of the comparative method were achieved contemporaneously in two fields of inquiry very remote from one another: the one was the work of Cuvier just mentioned, the other was the founding of the comparative philology of the Aryan languages by Franz Bopp in 1816. The work of Bopp exerted as powerful an influence throughout all the historical fields of study as Cuvier exerted in biology. The young men whose minds were receiving their formative impulses between 1825 and 1840, under the various influences of Cuvier and Saint-Hilaire, Lyell, Goethe, Bopp, and other such great leaders, began themselves to come to the foreground as leaders of thought about 1860, on the one hand, such men as Darwin, Gray, Huxley, and Wallace; on the other hand, such as Kuhn and Schleicher,

Maine, Maurer, Mommsen, Freeman, and Tylor. The point of the comparative method, in whatever field it may be applied, is that it brings before us a great number of objects so nearly alike that we are bound to assume for them an origin and general history in common, while at the same time they present such differences in detail as to suggest that some have advanced further than others in the direction in which all are traveling; some, again, have been abruptly arrested, others perhaps even turned aside from the path. In the attempt to classify such phenomena, whether in the historical or in the physical sciences, the conception of development is presented to the student with irresistible force. In the case of the Aryan languages no one would think of doubting their descent from a common original; just side by side is the parallel case of one subgroup of the Aryan languages, namely, the seven Romance languages which we know to have been developed out of the Latin since the Christian era. In these cases we can study the process of change resulting in forms that are more or less divergent from their originals. In one quarter a form is retained with little modification, in another it is completely blurred, as the Latin *metipsissimus* becomes *medesimo* in Italian, but *mismo* in Spanish, while in French there is nothing left of it but *même*. So in Sanskrit and in Lithuanian we find a most ingenious and elaborate system of conjugation and declension, which in such languages as Greek and Latin is more or less curtailed and altered, and which in English is almost completely lost. Yet in Old English there are quite enough vestiges of the system to enable us to identify it with the Lithuanian and Sanskrit.

So the student who applies the comparative method to the study of human customs and institutions is continually finding usages, beliefs, or laws existing in one part of the world that have long since ceased to exist in another part; yet where they have ceased to exist they have often left unmistakable traces of their former existence. In Australasia we find types of savagery ignorant of the bow and arrow; in aboriginal North America, a type of barbarism familiar with the art of pottery, but ignorant of domestic animals or of the use of metals; among the earliest Romans, a higher type of barbarism, familiar with iron and cattle, but ignorant of the alphabet. Along with such gradations in material culture we find associated gradations in ideas, in social structure, and in deep-seated customs. Thus, some kind of fetichism is apt to prevail in the lower stages of barbarism, and some form of polytheism in the higher stages. The units of composition in savage and barbarous societies are always the clan, the phratry, and the tribe. In the lower stages of barbarism we see such confederacies as those of the Iroquois; in the highest stage, at the dawn of civilization, we begin to find nations imperfectly

formed by conquest without incorporation, like aboriginal Peru or ancient Assyria. In the lower stages we see captives tortured to death, then at a later stage sacrificed to the tutelar deities, then later on enslaved and compelled to till the soil. Through all the earlier stages of culture, as in Australasia and aboriginal America, we find the marriage tie so loose and paternity so uncertain that kinship is reckoned only through the mother. But in the highest stage of barbarism, as among the earliest Greeks, Romans, and Jews, the more definite patriarchal family is developed and kinship begins to be reckoned through the father. It is only after that stage is reached that inheritance of property becomes fully developed, with the substitution of individual ownership for clan ownership, and so on to the development of testamentary succession, individual responsibility for delict and crime, and the substitution of contract for status. In all such instances, and countless others might be cited, we see the marks of an intelligible progression, a line of development which human ideas and institutions have followed. But in the most advanced societies we find numerous traces of such states of things as now exist only among savage or barbarous societies. Our own ancestors were once polytheists, with plenty of traces of fetichism. They were organized in clans, phratries, and tribes. There was a time when they used none but stone tools and weapons, when there was no private property in land, and no political structure higher than the tribe. Among the forefathers of the present civilized inhabitants of Europe are unmistakable traces of human sacrifices and of the reckoning of kinship through the mother only. When we have come to survey large groups of facts of this sort, the conclusion is irresistibly driven home to us that the more advanced societies have gone through various stages now represented here and there by less advanced societies; that there is a general path of social development, along which, owing to special circumstances, some peoples have advanced a great way, some a less way, some but a very little way; and that, by studying existing savages and barbarians, we get a valuable clew to the interpretation of prehistoric times. All these things are to-day commonplaces among students of history and archæology: sixty years ago they would have been scouted as unintelligible and idle vagaries. Yet to this change is entirely due the superior power of modern historical methods. Formerly the historian told anecdotes or discussed particular lines of policy; now he can do that as much as ever, but he can also study nation-building and discern some features of the general drift of events from the earliest to the most recent times.

If we leave the earth and its inhabitants and turn our attention to the starry heavens, we find plenty of subjects for comparison indicating that there is a general process going on, and that

this process has advanced much further in some places than in others. The general process may be roughly described as concentration of cosmical matter, with dissipation of heat. Along with this go sundry attendant or derivative chemical changes. We find gaseous nebulæ; stars ranked in different classes by their colors, perhaps indicating different stages of progress toward consolidation; then planets, first huge ones, like Saturn and Jupiter, with small density, tremendous atmospherical disturbances, and probably some remains of self-luminosity; then such as Mars, Earth, and Venus, with cool, vapor-laden atmospheres and conditions favorable to organic life; then smaller, quickly cooled and solidified globes like our barren moon; then cosmic rubbish like the asteroids and cosmic dust like the meteors. All, of course, are losing heat. Some have cooled too quickly to allow the development of life upon their surfaces; others are still too hot, but while in this stage can perhaps supply radiant heat and actinism for the support of life upon their neighbors. Obviously the gaseous nebula, being a body in an earlier stage of consolidation and containing a maximum of internal motion, is to be regarded as something like what suns and their planets were in a former stage of development.

Long before all these fruits of modern astronomical observation had been gathered, the contemplation of our sun as a consolidating and radiating body had suggested to one of the most profound thinkers that ever lived the famous nebular hypothesis as an account of the mode of development of our planetary system. The nebular hypothesis, set forth by Immanuel Kant in 1755, was the first constructive work toward a definite doctrine of evolution. The theory was restated in 1796 by Laplace, whose line of argument was very similar to Kant's. Within recent years it has received emendations and qualifications, but the fundamental conception of the nebulous mass acquiring spheroidal shape through rotation, and increasing in oblateness until at some stage in its shrinkage a portion of the equatorial surface is detached as a ring of fragments which ultimately coalesce into a satellite globe —this fundamental conception still remains as a good working hypothesis.

As we now look back over the illustrations here cited—and they are, of course, scanty enough in comparison with what might be adduced—it appears that about half a century ago the foremost minds of the world, with whatever group of phenomena they were occupied, had fallen and were more and more falling into a habit of regarding things not as having originated in the shape in which we now find them, but as having been slowly metamorphosed from some other shape through the agency of forces similar in nature to forces now at work. Whether planets, or mountains, or mollusks,

or subjunctive moods, or tribal confederacies were the things studied, the scholars who studied them most deeply and most fruitfully were those who studied them as phases in a process of development. The work of such scholars has formed the strong current of thought in our time, while the work of those who did not catch these new methods has been dropped by the way and forgotten. And as we look back to Newton's time we can see that ever since then the drift of scientific thought has been setting in this direction, and with increasing steadiness and force.

Now, what does all this drift of scientific opinion during more than two centuries mean? It can, of course, have but one meaning. It means that the world *is* in a process of development, and that gradually, as advancing knowledge has enabled us to take a sufficiently wide view of the world, we have come to see that it is so. The old statical conception of a world created all at once in its present shape was the result of very narrow experience; it was entertained when we knew only an extremely small segment of the world. Now that our experience has widened, it is outgrown and set aside forever; it is replaced by the dynamical conception of a world in a perpetual process of evolution from one state into another state. This dynamical conception has come to stay with us. Our theories as to what the process of evolution is may be more or less wrong and are confessedly tentative, as scientific theories should be. But the dynamical conception, which is not the work of any one man, be he Darwin or Spencer or any one else, but the result of the cumulative experience of the last two centuries, this is a permanent acquisition. We can no more revert to the statical conception than we can turn back the sun in his course. Whatever else the philosophy of future generations may be, it must be a philosophy of evolution.

It was not strange that among the younger men whose opinions were molded between 1830 and 1840 there should have been one of organizing genius, with a mind inexhaustibly fertile in suggestions, who should undertake to elaborate a general doctrine of evolution, to embrace in one grand coherent system of generalizations all the minor generalizations which workers in different departments of science were establishing. It is this prodigious work of construction that we owe to Herbert Spencer. He is the originator and author of what we know to-day as the doctrine of evolution, the doctrine which undertakes to formulate and put into scientific shape the conception of evolution toward which scientific investigation had so long been tending. In the mind of the general public there seems to be dire confusion with regard to Mr. Spencer and his relations to evolution and to Darwinism. Sometimes, I believe, he is even supposed to be chiefly a follower and expounder of Mr. Darwin! No doubt this is because

so many people mix up Darwinism with the doctrine of evolution, and have but the vaguest and haziest notions as to what it is all about. As I explained above, Mr. Darwin's great work was the discovery of natural selection and the demonstration of its agency in effecting specific changes in plants and animals; and in that work he was completely original. But plants and animals are only a part of the universe, though an important part, and with regard to universal evolution or any universal formula for evolution Darwinism had nothing to say. Such problems were beyond its scope.

The discovery of a universal formula for evolution, and the application of this formula to many diverse groups of phenomena, have been the great work of Mr. Spencer, and in this he has had no predecessor. His wealth of originality is immense, and it is unquestionable. But as the most original thinker must take his start from the general stock of ideas accumulated at his epoch, and more often than not begins by following a clew given him by somebody else, so it was with Mr. Spencer when about forty years ago he was working out his doctrine of evolution. The clew was not given him by Mr. Darwin. Darwinism was not yet born. Mr. Spencer's theory was worked out in all its parts, and most parts of it had been expounded in various published volumes and essays before the publication of The Origin of Species.

The clew which Mr. Spencer followed was given him by the great German embryologist Von Baer, and an adumbration of it may perhaps be traced back through Kaspar Friedrich Wolf to Linnæus. Hints of it may be found, too, in Goethe and in Schelling. The advance from simplicity to complexity in the development of an egg is too obvious to be overlooked by any one, and was remarked upon, I believe, by Harvey; but the analysis of what that advance consists in was a wonderfully suggestive piece of work. Von Baer's great book was published in 1829, just at the time when so many stimulating ideas were being enunciated, and its significant title was *Entwickelungsgeschichte*, or History of Evolution. It was well known that, so far as the senses can tell us, one ovum is indistinguishable from another, whether it be that of a man, a fish, or a parrot. The ovum is a structureless bit of organic matter, and in acquiring structure along with its growth in volume and mass, it proceeds through a series of differentiations, and the result is a change from homogeneity to heterogeneity. Such was Von Baer's conclusion, to which scanty justice is done by such a brief statement. As all know, his work marked an epoch in the study of embryology, for to observe and mark the successive differentiations in the embryos of a thousand animals were to write a thousand life-histories upon correct principles.

Here it was that Mr. Spencer started. As a young man he was

chiefly interested in the study of political government and in history so far as it helps the study of politics. A philosophical student of such subjects must naturally seek for a theory of evolution. If I may cite my own experience, it was largely the absorbing and overmastering passion for the study of history that first led me to study evolution in order to obtain a correct method. When one has frequent occasion to refer to the political and social *progress* of the human race, one likes to know what one is talking about. Mr. Spencer needed a theory of progress. He could see that the civilized part of mankind has undergone some change from a bestial, unsocial, perpetually fighting stage of savagery into a partially peaceful and comparatively humane and social stage, and that we may reasonably hope that the change in this direction will go on. He could see, too, that along with this change there has been a building up of tribes into nations, a division of labor, a differentiation of governmental functions, a series of changes in the relations of the individual to the community. To see so much as this is to whet one's craving for enlarged resources wherewith to study human progress. Mr. Spencer had a wide general acquaintance with botany, zoölogy, and allied studies. The question naturally occurred to him, Where do we find the process of development most completely exemplified from beginning to end, so that we can follow and exhaustively describe its consecutive phases? Obviously in the development of the ovum. There and only there do we get the whole process under our eyes from the first segmentation of the yolk to the death of the matured individual. In other groups of phenomena we can only see a small part of what is going on; they are too vast for us, as in astronomy, or too complicated, as in sociology. Elsewhere our evidences of development are more or less piecemeal and scattered, but in embryology we do get, at any rate, a connected story.

So Mr. Spencer took up Von Baer's problem and carried the solution of it much further than the great German naturalist. He showed that in the development of the ovum the change from homogeneity to heterogeneity is accompanied by a change from indefiniteness to definiteness; there are segregations of similarly differentiated units resulting in the formation of definite organs. He further showed that there is a parallel and equally important change from incoherence to coherence; along with the division of labor among the units there is an organization of labor; at first among the homogeneous units there is no subordination—to subtract one would not alter the general aspect; but at last among the heterogeneous organs there is such subordination and interdependence that to subtract any one is liable to undo the whole process and destroy the organism. In other words, integration is as much a feature of development as differentiation; the change is

not simply from a structureless whole into parts, but it is from a structureless whole into an organized whole with a consensus of different functions—and that is what we call an organism. So where Von Baer said that the evolution of the chick is a change from homogeneity to heterogeneity through successive differentiations, Mr. Spencer said that the evolution of the chick is a continuous change from indefinite incoherent homogeneity to definite coherent heterogeneity through successive differentiations and integrations.

But Mr. Spencer had now done something more than describe exhaustively the evolution of an individual organism. He had got a standard of high and low degrees of organization; and the next thing in order was to apply this standard to the whole hierarchy of animals and plants according to their classified relationships and their succession in geological time. This was done with most brilliant success. From the earliest records in the rocks the general advance in types of organization has been an advance in definiteness, coherence, and heterogeneity. The method of evolution in the life-history of the animal and vegetal kingdoms has been like the method of evolution in the life-history of the individual.

To go into the inorganic world with such a formula might seem rash. But as the growth of organization is essentially a particular kind of redistribution of matter and motion, and as redistribution of matter and motion is going on universally in the inorganic world, it is interesting to inquire whether in such simple approaches toward organization as we find there is any approach toward the characteristics of organic evolution as above described. It was easy for Mr. Spencer to show that the change from a nebula into a planetary system conforms to the definition of evolution in a way that is most striking and suggestive. But in studying the inorganic world Mr. Spencer was led to modify his formula in a way that vastly increased its scope. He came to see that the primary feature of evolution is an integration of matter and concomitant dissipation of motion. According to circumstances this process may or not be attended with extensive internal rearrangements and development of organization. The continuous internal rearrangement implied in the development of organization is possible only where there is a medium degree of mobility among the particles, a plasticity such as is secured only by those peculiar chemical combinations which make up what we call organic matter. In the inorganic world, where there is an approach to organization there is an adumbration of the law as realized in the organic world. But in the former what strikes us most is the concentration of the mass with the retention of but little internal mobility; in the latter what strikes us most is the

wonderful complication of the transformations wrought by the immense amount of internal mobility retained. These transformations are to us the mark, the distinguishing feature of life.

Having thus got the nature of the differences between the organic and inorganic worlds into a series of suggestive formulas, the next thing to be done was to inquire into the applicability of the law of evolution to the higher manifestations of vital activity—in other words, to psychical and social life. Here it was easy to point out analogies between the development of society and the development of an organism. Between a savage state of society and a civilized state it is easy to see the contrasts in complexity of life, in division of labor, in interdependence and coherence of operations and of interests. The difference resembles that between a vertebrate animal and a worm.

Snch analogies are instructive, because at the bottom of the phenomena there is a certain amount of real identity. But Mr. Spencer did not stop with analogies; he pursued his problem into much deeper regions. There is one manifest distinction between a society and an organism. In the organism the conscious life, the psychical life, is not in the parts but in the whole; but in a society there is no such thing as corporate consciousness: the psychical life is all in the individual men and women. The highest development of this psychical life is the end for which the world exists. The object of social life is the highest spiritual welfare of the individual members of society. The individual human soul thus comes to be as much the center of the Spencerian world as it was the center of the world of mediæval theology; and the history of the evolution of conscious intelligence becomes a theme of surpassing interest.

This is the part of his subject which Mr. Spencer has handled in the most masterly manner. Nothing in the literature of psychology is more remarkable than the long-sustained analysis in which he starts with complicated acts of quantitative reasoning and resolves them into their elementary processes, and then goes on to simpler acts of judgment and perception, and then down to sensation, and so on, resolving and resolving, until he gets down to the simple homogeneous psychical shocks or pulses in the manifold compounding and recompounding of which all mental action consists. Then, starting from that conception of life as the continuous adjustment of inner relations within the organism to outer relations in the environment—a conception of which he made such brilliant use in his Principles of Biology—he shows how the psychical life gradually becomes specialized in certain classes of adjustments or correspondences, and how the development of psychical life consists in a progressive differentiation and integration of such correspondences. Intellectual life is shown to have arisen

by slow gradations, and the special interpretations of reflex action, instinct, memory, reason, emotion, and will are such as to make the Principles of Psychology indubitably the most suggestive book upon mental phenomena that was ever written.

Toward the end of the first edition of The Origin of Species, published in 1859, Mr. Darwin looked forward to a distant future when the conception of gradual development might be applied to the phenomena of intelligence. But the first edition of the Principles of Psychology, in which this was so successfully done, had already been published four years before—in 1855—so that Mr. Darwin in later editions was obliged to modify his statement and confess that, instead of looking so far forward, he had better have looked about him. I remember hearing Mr. Darwin laugh merrily over this at his own expense.

This extension of the doctrine of evolution to psychical phenomena was what made it a universal doctrine, an account of the way in which the world, as we know it, has come to be. There is no subject great or small that has not come to be affected by the doctrine, and, whether men realize it or not, there is no nook or corner in speculative science where they can get away from the sweep of Mr. Spencer's thought.

This extension of the doctrine to psychical phenomena is by many people misunderstood. The Principles of Psychology is a marvel of straightforward and lucid statement; but, from its immense reach and from the abstruseness of the subject, it is not easy reading. It requires a sustained attention such as few people can command except on subjects with which they are already familiar. Hence few people read it in comparison with the number who have somehow got it into their heads that Mr. Spencer tries to explain mind as evolved out of matter, and is therefore a materialist. How many worthy critics have been heard to object to the doctrine of evolution that you can not deduce mind from the primeval nebula unless the germs of mind were present already! But that is just what Mr. Spencer says himself. I have heard him say it more than once, and his books contain many passages of equivalent import.* He never misses an opportunity for attacking the doctrine that mind can be explained as evolved from matter. But, in spite of this, a great many people suppose that the gradual evolution of mind *must* mean its evolution out of matter, and are deaf to arguments of which they do not perceive the bearing. Hence Mr. Spencer is so commonly accredited with the doctrine which he so earnestly repudiates.

But there is another reason why people are apt to suppose

* See, for example, Principles of Psychology, vol. ii, pp. 145–162.

the doctrine of evolution to be materialistic in its implications. There are able writers who have done good service in illustrating portions of the general doctrine, and are at the same time avowed materialists. One may be a materialist, whatever his scientific theory of things; and to such a person the materialism naturally seems to be a logical consequence from the scientific theory. We have received this evening a communication from Prof. Ernst Haeckel, of Jena, in which he lays down five theses regarding the doctrine of evolution:

1. "The general doctrine appears to be already unassailably founded.

2. "Thereby every supernatural creation is completely excluded.

3. "Transformism and the theory of descent are inseparable constituent parts of the doctrine of evolution.

4. "The necessary consequence of this last conclusion is the descent of man from a series of vertebrates."

So far, very good; we are within the limits of scientific competence, where Prof. Haeckel is strong. But now, in his fifth thesis, he enters the region of metaphysics—the transcendental region, which science has no competent methods of exploring—and commits himself to a dogmatic assertion:

5. "The belief in an 'immortal soul' and in 'a personal God' are therewith" (i. e., with the four preceding statements) "completely ununitable (*völlig unvereinbar*)."

Now, if Prof. Haeckel had contented himself with asserting that these two beliefs are not susceptible of scientific demonstration; if he had simply said that they are beliefs concerning which a scientific man, in his scientific capacity, ought to refrain from making assertions because Science knows nothing whatever about the subject—he would have occupied an impregnable position. His fifth thesis would have been as indisputable as his first four. But Prof. Haeckel does not stop here. He declares virtually that, if an evolutionist is found entertaining the beliefs in a personal God and an immortal soul, nevertheless these beliefs are not philosophically reconcilable with his scientific theory of things, but are mere remnants of an old-fashioned superstition from which he has not succeeded in freeing himself.

Here one must pause to inquire what Prof. Haeckel means by "a personal God." If he refers to the Latin conception of a God remote from the world of phenomena and manifested only through occasional interference—the conception that has until lately prevailed in the Western world since the time of St. Augustine—then we may agree with him; the practical effect of the doctrine of evolution is to abolish such a conception. But with regard to the Greek conception entertained by St. Athanasius; the concep-

tion of God as immanent in the world of phenomena and manifested in every throb of its mighty rhythmical life; the deity that Richard Hooker, prince of English churchmen, had in mind when he wrote of Natural Law that "her seat is the bosom of God and her voice the harmony of the world"—with regard to this conception the practical effect of the doctrine of evolution is not to abolish but to strengthen and confirm it. For, into whatever province of Nature we carry our researches, the more deeply we penetrate into its laws and methods of action, the more clearly do we see that all provinces of Nature are parts of an organic whole animated by a single principle of life that is infinite and eternal. I have no doubt Prof. Haeckel would not only admit this, but would scout any other view as inconsistent with the monism which he professes. But he would say that this infinite and eternal principle of life is not psychical, and therefore can not be called in any sense "a personal God." In an ultimate analysis, I suspect, Prof. Haeckel's ubiquitous monistic principle would turn out to be neither more nor less than Dr. Büchner's mechanical force (*Kraft*). On the other hand, I have sought to show—in my little book The Idea of God—that the Infinite and Eternal Power that animates the universe must be psychical in its nature, that any attempt to reduce it to mechanical force must end in absurdity, and that the only kind of monism which will stand the test of an ultimate analysis is monotheism. While in the chapter on Anthropomorphic Theism, in my Cosmic Philosophy, I have taken great pains to point out the difficulties in which (as finite thinkers) we are involved when we try to conceive the Infinite and Eternal Power as psychical in His nature, I have, in the chapter on Matter and Spirit, in that same book, taken equal pains to show that we are logically compelled thus to conceive Him.

One's attitude toward such problems is likely to be determined by one's fundamental conception of psychical life. To a materialist the ultimate power is mechanical force, and psychical life is nothing but the temporary and local result of fleeting collocations of material elements in the shape of nervous systems. Into the endless circuit of transformations of molecular motion, says the materialist, there enter certain phases which we call feelings and thoughts; they are part of the circuit, they arise out of motions of material molecules and disappear by being retransformed into such motions; hence, with the death of the organism in which such motions have been temporarily gathered into a kind of unity, all psychical activity and all personality are *ipso facto* abolished. Such is the materialistic doctrine, and such, I presume, is what Prof. Haeckel has in mind when he asserts that the belief in an immortal soul is incompatible with the doctrine of evolution. The theory commonly called that of the correlation of forces, and

which might equally well or better be called the theory of the metamorphosis of motions, is indispensable to the doctrine of evolution. But for the theory that light, heat, electricity, and nerve-action are different modes of undulatory motion transformable one into another, and that similar modes of motion are liberated by the chemical processes going on within the animal or vegetal organism, Mr. Spencer's work could never have been done. That theory of correlation and transformation is now generally accepted, and is often appealed to by materialists. A century ago Cabanis said that the brain secretes thought as the liver secretes bile. If he were alive to-day, he would doubtless smile at this old form of expression as crude, and would adopt a more subtle phrase; he would say that "thought is transformed motion."

Against this interpretation I have maintained that the theory of correlation not only fails to support it, but actually overthrows it. The arguments may be found in the chapter on Matter and Spirit in my Cosmic Philosophy, published in 1874, and in the essay entitled A Crumb for the Modern Symposium, written in 1877 and reprinted in Darwinism and other Essays.* Their purport is, that in tracing the correlation of motions into the organism through the nervous system, and out again, we are bound to get an account of each step in terms of motion. Unless we can show that every unit of motion that disappears is transformed into an exact quantitative equivalent, our theory of correlation breaks down; but when we have shown this we shall have given a complete account of the whole affair without taking any heed whatever of thought, feeling, or consciousness. In other words, these psychical activities do not enter into the circuit, but stand outside of it, as a segment of a circle may stand outside a portion of an entire circumference with which it is concentric. Motion is never transformed into thought, but only into some other form of measurable (in fact, or, at any rate, in theory measurable) motion that takes place in nerve-threads and ganglia. *It is not the thought, but the nerve-action that accompanies the thought, that is really "transformed motion."* I say that, if we are going to verify the theory of correlation, it must be done (actually or theoretically) by measurement; quantitative equivalence must be proved at every step; and hence we must not change our unit of measurement; from first to last it must be a unit of motion: if we change it for a moment, our theory of correlation that moment collapses. I say, therefore, that the theory of correlation and equivalence of forces lends no support whatever to materialism. On the contrary, its manifest implication is that psychical life can not be a mere product of temporary collocations of matter.

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* See also Excursions of an Evolutionist, pp. 274–282.

The argument here set forth is my own. When I first used it I had never met with it anywhere in books or conversation. Whether it has since been employed by other writers I do not know, for during the past fifteen years I have read very few books on such subjects. At all events, it is an argument for which I am ready to bear the full responsibility. Some doubt has recently been expressed whether Mr. Spencer would admit the force of this argument. It has been urged by Mr. S. H. Wilder, in two able papers published in the New York Daily Tribune, June 13 and July 4, 1890, that the use of this argument marks a radical divergence on my part from Mr. Spencer's own position. It is true that in several passages of First Principles there are statements which either imply or distinctly assert that motion can be transformed into feeling and thought—e. g., "Those modes of the Unknowable which we call heat, light, chemical affinity, etc., are alike transformable into each other, and into those modes of the Unknowable which we distinguish as sensation, emotion, thought: these, in their turns, being directly or indirectly retransformable into the original shapes" (First Principles, second edition, 1867, p. 217); and again it is said "to be a necessary deduction from the law of correlation, that what exists in consciousness under the form of feeling is transformable into an equivalent of mechanical motion," etc. (First Principles, second edition, p. 558). Now, if this, as literally interpreted, be Mr. Spencer's deliberate opinion, I entirely dissent from it. To speak of quantitative equivalence between a unit of feeling and a unit of motion seems to me to be talking nonsense—to be combining terms which severally possess a meaning into a phrase which has no meaning. I am, therefore, inclined to think that the above sentences, literally interpreted, do not really convey Mr. Spencer's opinion. They appear manifestly inconsistent, moreover, with other passages in which he has taken much more pains to explain his position (e. g., Principles of Psychology, pp. 158–161, 616–627). In the sentence of p. 558 of First Principles, Mr. Spencer appears to me to mean that the nerve-action, which is the objective concomitant of what is subjectively known as feeling, is transformable into an equivalent of mechanical motion. When he wrote that sentence perhaps he had not shaped the case quite so distinctly in his own mind as he had a few years later, when he made the more elaborate statements in the Psychology. Though in these more elaborate statements he does not assert the doctrine I have here maintained, yet they seem consistent with it. When I was finishing the chapter on Matter and Spirit, in my room in London one afternoon in February, 1874, Mr. Spencer came in, and I read to him nearly the whole chapter, including my argument from correlation above mentioned. He expressed warm ap-

proval of the chapter, without making any specific qualifications. In the course of the chapter I had occasion to quote a passage from the Psychology (vol. i, p. 158; cf. Cosmic Philosophy, vol. ii, p. 444), in which Mr. Spencer twice inadvertently used the phrase "nervous shock" where he meant "psychical shock." As his object was to keep the psychical phenomena and their cerebral concomitants distinct in his argument, this colloquial use of the word "nervous" was liable to puzzle the reader, and give the querulous critic a chance to charge Mr. Spencer with the materialistic implications which it was his express purpose to avoid. Accordingly, in my quotation I changed the word "nervous" to "psychical," using brackets and explaining my reasons. On showing all this to Mr. Spencer, he desired me to add in a foot-note that he thoroughly approved the emendation.

I mention this incident because our common, every-day speech abounds in expressions that have a materialistic flavor; and sometimes in serious writing an author's sheer intentness upon his main argument may lead him to overlook some familiar form of expression which, when thrown into a precise and formal context, will strike the reader in a very different way from what the author intended. I am inclined to explain in this way the passages in First Principles which are perhaps chiefly responsible for the charge of materialism that has so often and so wrongly been brought up against the doctrine of evolution.

As regards the theological implications of the doctrine of evolution, I have never undertaken to speak for Mr. Spencer; on such transcendental subjects it is quite enough if one speaks for one's self. It is told of Diogenes that, on listening one day to a sophistical argument against the possibility of motion, he grimly got up out of his tub and walked across the street. Whether his adversaries were convinced or not, we are not told. Probably not; it is but seldom that adversaries are convinced. So, when Prof. Haeckel declares that belief in a "personal God" and an "immortal soul" are incompatible with acceptance of the doctrine of evolution, I can only say, for myself—however much or little the personal experience may be worth—I find that the beliefs in the psychical nature of God and in the immortality of the human soul seem to harmonize infinitely better with my general system of cosmic philosophy than the negation of these beliefs. If Prof. Haeckel, or any other writer, prefers a materialistic interpretation, very well. I neither quarrel with him nor seek to convert him; but I do not agree with him. I do not pretend that my opinion on these matters is susceptible of scientific demonstration. Neither is his. I say, then, that his fifth thesis has no business in a series of scientific generalizations about the doctrine of evolution.

Far beyond the limits of what scientific methods, based upon

our brief terrestrial experience, can demonstrate, there lies on every side a region with regard to which Science can only suggest questions. As Goethe so profoundly says:

"Willst du ins Unendliche streiten,
Geh' nur im Endlichen nach allen Seiten."*

It is of surpassing interest that the particular generalization which has been extended into a universal formula of evolution should have been the generalization of the development of an ovum. In enlarging the sphere of life in such wise as to make the whole universe seem actuated by a single principle of life, we are introduced to regions of sublime speculation. The doctrine of evolution, which affects our thought about all things, brings before us with vividness the conception of an ever-present God—not an absentee God who once manufactured a cosmic machine capable of running itself except for a little jog or poke here and there in the shape of a special providence. The doctrine of evolution destroys the conception of the world as a machine. It makes God our constant refuge and support, and Nature his true revelation; and when all its religious implications shall have been set forth, it will be seen to be the most potent ally that Christianity has ever had in elevating mankind.

Mr. G. L. Gomme makes a distinction between the anthropological and the literary schools of folk-lorists. The work of the former has only just begun; the latter has been at work for a long time, although the results it has obtained do not seem to be advancing beyond the dictum that what is recorded chronologically earlier must be the parent of that which is recorded later, the second being the central point of importance, not the thing recorded. The results of the anthropological school show great and continuing advance. From analysis of folk tales it becomes clear that in the majority of stories the central part of the plot is some savage or rudely barbarous idea or custom. By analyzing custom and belief, and tracing out their geographical distribution in each country, much would be gained toward placing folk lore as one of the factors for elucidating the prehistoric life of man. As examples of such analysis, baptism beliefs, witchcraft customs, the burning of the clavie, and some sacrificial rites in Devonshire, were given in the author's paper, and the evidence was pointed out which suggests that they contain some unpublished details of the practices of the stone age. Further, Mr. Gomme urged the importance of studying folk lore by exact methods.

According to Mr. W. T. Thiselton Dyer, of Kew Gardens, Alpine plants are the reverse of hardy. He believes that they are for the most part intolerant of very low temperature, and are certainly extremely impatient of humidity during the comparatively long period when they are not in active growth. For these reasons the collections at Kew are wintered under glass. These peculiarities are accounted for by the fact that in nature, except for a short time, Alpine plants are covered with snow, which keeps them dry and protects them from a very low temperature.

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* ["If thou wouldst press into the infinite, go but to all parts of the finite."]

NEW CHAPTERS IN THE WARFARE OF SCIENCE.

XIII. FROM FETICH TO HYGIENE.

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II.

WE have now seen how powerful in various nations especially obedient to theology were the forces working in opposition to the evolution of hygiene. We shall find this same opposition, less effective, it is true, but still acting with great power in countries which had become somewhat emancipated from theological control. In England, during the mediæval period, persecutions of Jews were occasionally resorted to, and here and there we hear of dealings with witches; but, as torture was rarely used in England, there were few of those torture-born confessions of persons charged with producing plague which in other countries gave rise to wide-spread cruelties. Down to the sixteenth and seventeenth centuries the filthiness in the ordinary mode of life in England was such as we can now hardly conceive: fermenting organic material was allowed to accumulate and become a part of the earthen floors of rural dwellings; and this undoubtedly developed the germs of many diseases. In his noted letter to the physician of Cardinal Wolsey, Erasmus describes the filth thus incorporated into the floors of English houses, and, what is of far more importance, he had an inkling of the true cause of the wasting diseases of the period. He says, "If I entered into a chamber which had been uninhabited for months, I was immediately seized with a fever." He ascribed the fearful plague of the sweating sickness to this cause. So, too, the noted Dr. Caius advised sanitary precautions against the plague; and in after-generations, Mead, Pringle, and others urged them; but the prevailing thought was too strong, and little was done. Even the floor of the presence-chamber of Queen Elizabeth in Greenwich Palace was "covered with hay, after the English fashion," as one of the chroniclers tells us. In the seventeenth century, aid in these great scourges was mainly sought in special church services; the foremost English churchmen during that century being greatly given to study of the early fathers of the Church, the theological theory of disease, so dear to the fathers, still held sway, and this was the case when the various visitations reached their climax in the great plague of London in 1665, which swept off more than a hundred thousand people from that city. The attempts at meeting it by sanitary measures were few and poor; the medical system of the

time was still largely tinctured by superstitions resulting from mediæval modes of thought; hence that plague was generally attributed to the divine wrath caused by "the prophaning of the Sabbath." Texts from Numbers, the Psalms, Zechariah, and the Apocalypse were dwelt upon in the pulpits to show that plagues are sent by the Almighty to punish sin; and perhaps the most ghastly figure among all those fearful scenes described by De Foe is that of the naked fanatic walking up and down the streets with a pan of fiery coals upon his head, and, after the manner of Jonah at Nineveh, proclaiming woe to the city and its destruction in forty days.

That sin caused this plague is certain, but it was sanitary sin; both before and after this culmination of the disease cases of plague were constantly occurring in London throughout the seventeenth century; but about the beginning of the eighteenth century it began to disappear; the great fire had done a good work by sweeping off many causes and centers of infection, and there had come wider streets, better pavements, and improved water-supply; so that with the disappearance of the plague, other diseases, especially dysenteries, which had formerly raged in the city, became much less frequent.

But while these epidemics were thus checked in London, others developed by sanitary sin raged fearfully both there and elsewhere, and of these perhaps the most fearful was the jail-fever. The prisons of that period were vile beyond belief. Men were confined in dungeons rarely if ever disinfected after the death of previous occupants, and on corridors connecting directly with the foulest sewers; there was no proper disinfection, ventilation, or drainage; hence in most of the large prisons for criminals or debtors the jail-fever was supreme, and from these centers it frequently spread through the adjacent towns. This was especially the case during the sixteenth and seventeenth centuries. In the Black Assize at Oxford in 1577 the chief baron, the sheriff, and about three hundred men died within forty hours. Lord Bacon declared the jail-fever "the most pernicious infection next to the plague." In 1730, at the Dorsetshire Assize, the chief baron and many lawyers were killed by it. The High Sheriff of Somerset also took the disease and died. A single Scotch regiment being infected from some prisoners, lost no less than two hundred. In 1750, the disease was so virulent at Newgate, in the heart of London, that two judges, the lord mayor, sundry aldermen, and many others died of it.

It is worth noting that while efforts at sanitary dealing with this state of things were few, the theological spirit developed special forms of prayer for prisoners, and especially that a new prayer was placed in the Irish Prayer-book.

These forms of prayer seem to have been the main reliance through the first half of the eighteenth century. But about 1750 began the work of John Howard: among other evidences of saintship he visited the prisons of England, made known their condition to the world, and never rested until they were greatly improved. Then he applied the same benevolent activity to prisons in other countries, in the far East and in southern Europe, and finally laid down his life, a victim to disease contracted on one of his missions of mercy; but the hygienic reforms he began were developed more and more until this fearful blot upon modern civilization was removed.*

The same thing was seen in the Protestant colonies of America; but here, while plagues were steadily attributed to divine wrath or satanic malice, there was one case in which it was claimed that such a visitation was due to the divine mercy: the pestilence among the *Indians*, before the arrival of the Plymouth Colony, was attributed in a notable work of that period to the divine purpose of clearing New England for the heralds of the gospel; on the other hand, the plagues which destroyed the *white* population were attributed by the same authority to devils and witches. In Increase Mather's Wonders of the Invisible World, published at Boston in 1693, we have striking examples of this. The great Puritan divine tells us:

"Plagues are some of those woes, with which the Divil troubles us. It is said of the Israelites, in 1 Cor. 10. 10. *They were destroyed of the destroyer.* That is, they had the Plague among them. 'Tis the Destroyer, or the Divil, that scatters Plagues about the World: Pestilential and Contagious Diseases, 'tis the Divel, who do's oftentimes Invade us with them. 'Tis no uneasy thing, for the Divel, to impregnate the Air about us, with such Malignant Salts, as meeting with the Salt of our Microcosm, shall immediately cast us into that Fermentation and Putrefaction, which

* For Erasmus, see the letter cited in Bascome, History of Epidemic Pestilences, London, 1851. For account of the condition of Queen Elizabeth's presence-chamber, see the same, p. 206. See also the same for attempts at sanitation by Caius, Mead, Pringle, and others. See Baas and various medical authorities. For the plague in London, see Green's History of the English People, chap. ix, sec. 2; and for a more detailed account, see Lingard, History of England, enlarged edition of 1849, vol. ix, p. 107 *et seq.* For the London plague as a punishment for Sabbath-breaking, see A divine Tragedie lately acted, A collection of sundrie memorable examples of God's judgements upon Sabbath Breakers and other like libertines, etc. By that worthy Divine, Mr. Henry Burton, 1641. The book gives fifty-six accounts of Sabbath-breakers sorely punished, generally struck dead, in England, with places, names, and dates. For a general account of the condition of London in the sixteenth and seventeenth centuries, and the diminution of the plague by the rebuilding of some parts of the city after the great fire, see Lecky, History of England in the Eighteenth Century, vol. i, pp. 592, 593. For the jail-fever, see Lecky, vol. i, pp. 500–505.

will utterly dissolve All the Vital Tyes within us; Ev'n as an Aqua Fortis, made with a conjunction of Nitre and Vitriol, Corrodes what it Siezes upon. And when the Divel has raised those Arsenical Fumes, which become Venomous Quivers full of Terrible Arrows, how easily can he shoot the deleterious Miasms into those Juices or Bowels of Mens Bodies, which will soon Enflame them with a Mortal Fire! Hence come such Plagues, as that Beesome of Destruction which within our memory swept away such a throng of people from one English City in one Visitation: and hence those Infectious Feavers, which are but so many Disguised Plagues among us, Causing Epidemical Desolations" (pp. 17 and 18).

Mather gives several instances of witches causing diseases, and speaks of "some long Bow'd down under such a Spirit of Infirmity," being "Marvelously Recovered upon the Death of the Witches," of which he gives an instance. He also gives an instance where a patient "was brought unto death's door and so remained until the witch was taken and carried away by the constable, when he began at once to recover and was soon well."*

In France we see, during generation after generation, a similar history evolved; pestilence after pestilence came, and was met by various fetiches. Noteworthy is the plague at Marseilles near the beginning of the last century. The chronicles of its sway are ghastly. They speak of great heaps of the unburied dead in the public places, "forming pestilential volcanoes"; of plague-stricken men and women in delirium wandering naked through the streets; of churches and shrines thronged with great crowds shrieking for mercy; of other crowds flinging themselves into the wildest debauchery; of robber bands plundering the dead and assassinating the dying; of three thousand neglected children collected in one hospital and then left to die; and of the death-roll numbering at last fifty thousand out of a population of less than ninety thousand.

In the midst of these fearful scenes stood a body of men and women worthy to be held in eternal honor—the physicians from Paris and Montpellier; the mayor of the city, and one or two of his associates; but, above all, the Chevalier Roze and Bishop Belzunce. The history of these men may well make us glory in human nature; but in all this noble group the figure of Belzunce

* For the passages cited from Increase Mather, see in his book as cited, pp. 17, 18, also 134, 145. Johnson's History of New England, published in London in 1654, declares that "By this meanes Christ . . . not only made roome for His people to plant, but also tamed the hard and cruell hearts of these barbarous Indians, insomuch that halfe a handful of His people landing not long after in Plymouth Plantation, found little resistance." See the History of New England, by Edward Johnson, London, 1654. Reprinted in Massachusett's Historical Society's Collection, second series, vol. i, p. 67.

is the most striking. Nobly and firmly, when so many others even among the regular and secular ecclesiastics fled, he stood by his flock: day and night he was at work in the hospitals, cheering the living, comforting the dying, and doing what was possible for the decent disposal of the dead. In him were united the two great antagonistic currents of religion and of theology. As a theologian he organized processions and expiatory services, which, it must be confessed, rather increased the sway of the disease than diminished it; moreover, he accepted that wild dream of a hysterical nun—the worship of the material, physical sacred heart of Jesus—and was one of the first to consecrate his diocese to it; but, on the other hand, the religious spirit gave in him one of its most beautiful manifestations in that or any other century: justly have the people of Marseilles placed his statue in the midst of their city in an attitude of prayer and blessing.

In every part of Europe and America, down to a recent period, we find pestilences resulting from carelessness or superstition still called "inscrutable providences." As late as the end of the eighteenth century, when great epidemics made fearful havoc in Austria, the main means against them seem to have been the special "witch-doctors"—that is, monks who cast out devils. To seek the aid of physicians was, in the neighborhood of these monastic centers, very generally considered impious, and the enormous death-rate in such neighborhoods was only diminished in the present century when scientific hygiene began to make its way.

The old view of pestilence had also its full course in Calvinistic Scotland—the only difference being that, while in Roman Catholic countries relief was sought by fetiches, gifts, processions, exorcisms, and works of expiation, promoted by priests; in Scotland, after the Reformation, it was sought in fast-days established by Presbyterian elders. Accounts of the filthiness of Scotch cities and villages, as well as of ordinary dwellings, down to a period well within this century, seem monstrous. All that in these days is swept into the sewers, was in those allowed to remain around the houses or thrown into the streets. The old theological theory that "vain is the hand of man," checked scientific thought and paralyzed sanitary endeavor. The result was natural: between the thirteenth and seventeenth centuries thirty notable epidemics swept the country, and some of them carried off multitudes; but as a rule these never suggested sanitary improvement; they were called "visitations," attributed to divine wrath against human sin, and the work of the authorities was to announce the particular sin concerned, and to declaim against it. Amazing theories were thus propounded—theories which led to spasms of

severity; and, in some of these, offenses generally punished much less severely were visited with death. Every pulpit interpreted the ways of God to man in such seasons so as rather to increase than to diminish the pestilence. The effect of thus seeking supernatural causes rather than natural may be seen in such facts as the death by plague of one fourth of the whole population of the city of Perth in a single year of the fifteenth century; other towns suffering similarly both then and afterward.

Here and there, physicians more wisely inspired endeavored to push sanitary measures, and in 1585 attempts were made to clean the streets of Edinburgh, but the chroniclers tell us that "the magistrates and ministers gave no heed." One sort of calamity, indeed, came in as a mercy—the great fires which swept through the cities, clearing and cleaning them. Though the town council of Edinburgh declared the noted fire of 1700 "a fearful rebuke of God," it was observed that, after it had done its work, disease and death were greatly diminished.*

But by those standing in the higher places of thought some glimpses of scientific truth had already been obtained, and attempts at compromise between theology and science in this field began to be made, not only by ecclesiastics, but first of all, as far back as the seventeenth century, by a man of science, eminent both for attainments and character—Robert Boyle. Inspired by the discoveries in other fields, which had swept away so much of theological thought, he could no longer resist the conviction that some epidemics are due, in his own words, "to a tragical concourse of natural causes"; but he argued that some of these may be the result of divine interpositions provoked by human sins. As time went on, great difficulties showed themselves in the way of this compromise—difficulties theological not less than difficulties scientific. To a Catholic it was more and more hard to explain the theological grounds why so many orthodox cities, firm in the faith, were punished, and so many heretical cities spared, and why, in regions devoted to the Church, the poorer people, whose faith in theological fetiches was unquestioning, died in times of pestilence like flies, while skeptics so frequently escaped. Difficulties of the same sort beset devoted Protestants; they, too, might well ask why it was that the devout peasantry in their humble cottages perished, while so much larger a proportion of the more skeptical upper classes were untouched.

* For the plague at Marseilles and its depopulation, see Henri Martin, Histoire de France, vol. xv, especially document cited in appendix; also Gibbon, Decline and Fall, chap. xliii; also Rambaud. For the resort to witch-doctors in Austria against pestilence, down to the end of the eighteenth century, see Biedermann, Deutschland im Achtzehnten Jahrhundert. For the reign of filth and pestilence in Scotland, see Charles Rogers, D. D., Social Life in Scotland, Edinburgh, 1884, vol. i, pp. 305–316; see also Buckle's second volume.

Gradually it dawned both upon Catholic and Protestant countries that, if any sin be punished by pestilence, it is the sin of filthiness; more and more it began to be seen by thinking men of both religions that Wesley's great dictum stated even less than the truth; that not only was "cleanliness akin to godliness," but that, as a means of keeping off pestilence, it was far superior to godliness as godliness was then generally understood.*

The recent history of sanitation in all civilized countries shows triumphs which may well fill us with wonder, did there not rise within us a far greater wonder that they were so long delayed. Amazing is it to see how near the world has come again and again to discovering the key to the cause and cure of pestilence. It is now a matter of the simplest elementary knowledge that some of the worst epidemics are conveyed in water. But this fact seems to have been discovered many times in human history. In the Peloponnesian war the Greeks asserted that their enemies had poisoned their cisterns; in the middle ages the people generally declared that the Jews had poisoned their wells; and as late as the cholera of 1832 the Parisian mob charged the water-carriers who distributed water for drinking purposes from the Seine, polluted as it was by sewage, with poisoning the water, and in some cases murdered them for it; so far did this feeling go, that locked covers were sometimes placed upon the water-buckets. Had not such men as Roger Bacon and his long line of successors been thwarted by theological authority—had not such men as Thomas Aquinas, Vincent de Beauvais, and Albert the Great been drawn or driven from the paths of science into the dark, tortuous paths of theology, leading nowhither, the world to-day, at the end of the nineteenth century, would have arrived at the solution of great problems and the enjoyment of great results which will only be reached at the end of the twentieth century, and even in generations more remote. Diseases like pulmonary consumption, scarlet fever, diphtheria, pneumonia, and *la grippe*, which now carry off so many most precious lives, would have long since ceased to scourge the world.

Still, there is one great cause for joy: the law governing the relation of theology to disease is now well before the world, and it is seen in the striking fact that just in proportion as the world progressed from the sway of Hippocrates to that of the ages of faith, so it progressed in the frequency and severity of great pestilences; and, on the other hand, just in proportion as the world has receded from that period when theology was all-pervading and all-controlling, plague after plague has disappeared, and

* For Boyle's attempt at compromise, see Discourse on the Air, in his works, vol. iv, pp. 288, 289, cited by Buckle, vol. i, pp. 128, 129, note.

those remaining have become less and less frequent and virulent.*

The recent history of hygiene in all countries shows a long series of victories, and these may well be studied in Great Britain and the United States. In the former, though there had been many warnings from eminent physicians, and, above all, in the seventeenth and eighteenth centuries, from men like Caius, Mead, and Pringle, the result was far short of what might have been gained; and it was only in the year 1838 that a systematic sanitary effort was begun in England by the public authorities. The state of things at that time, though by comparison with the middle ages happy, was, by comparison with what has since been gained, fearful; the death-rate among all classes was high, but among the poor it was ghastly. Out of seventy-seven thousand paupers in London during the years 1837 and 1838, fourteen thousand were suffering from fever, and of these nearly six thousand from typhus. In many other parts of the British Islands the sanitary condition was no better. A noble body of men grappled with the problem, and in a few years one of these rose above his fellows—the late Edwin Chadwick. The opposition to his work was bitter, and, though many churchmen aided him, the support given by theologians and ecclesiastics as a whole was very far short of what it should have been. Too many of them were occupied in that most costly of all processes, "the saving of souls" by the inculcation of dogma. Yet some of the higher ecclesiastics and many of the lesser clergy did much, sometimes risking their lives, and one of them, Sidney Godolphin Osborne, deserves lasting memory for his struggle to make known the sanitary wants of the peasantry.

Chadwick began to be widely known in 1848 as a member of the Board of Health, and was driven out for a time for overzeal; but from one point or another, during forty years, he fought the opposition, developed the new work, and one of the best exhibits of its results is shown in his address before the Sanitary Conference at Brighton in 1888. From this and other perfectly trustworthy sources some idea may be gained of the triumph of the scientific over the theological method of dealing with disease, whether epidemic or sporadic.

In the latter half of the seventeenth century the mortality of London is estimated to have been not less than eighty per thousand; about the middle of this century it stood at twenty-four in a thousand; in 1889 it stood at less than eighteen in a thousand; and in many parts the most recent statistics show that it has been

* For the charge of poisoning water and producing pestilence among the Greeks, see Grote's History of Greece, vi, 213. For a similar charge against the Jews in the middle ages, see various histories already cited; and for the great popular prejudice against water-carriers at Paris in recent times, see the larger recent French histories.

brought down to fourteen or fifteen in a thousand. A quarter of a century ago the death-rate from disease in the Royal Guards at London was twenty per thousand; in 1888 it had been reduced to six in a thousand. In the army generally it had been seventeen in a thousand, but it has been reduced until it now stands at eight. In the old Indian army it had been sixty-nine in a thousand; but of late it has been brought down, first to twenty, and finally to fourteen. Mr. Chadwick in his speech proved that much more might be done, for he called attention to the German army, where the death-rate from disease has been reduced to between five and six in a thousand. Between 1871 and 1880 the death-rate in England among men fell more than four in a thousand, and among women more than six in a thousand. In the decade between 1851 and 1860 there died of zymotic diseases over four thousand persons in every million throughout England; these numbers have declined until in 1888 there died less than two thousand in every million. As to the scourge which, next to plagues like the black death, was formerly the most dreaded—small-pox—there died of it in London during the year 1890 just one person. Drainage in Bristol reduced the death-rate by consumption from 4·4 to 2·3; at Cardiff, from 3·47 to 2·31; and in all England and Wales from 2·68 in 1851 to 1·55 in 1888.

What can be accomplished by better sanitation is also seen today by a comparison between the death-rate among the children outside and inside the charity schools. The death-rate among those outside in 1881 was twelve in a thousand; while inside, where the children were under sanitary regulations, maintained by competent authorities, it has been brought down, first to eight, then to four, and finally to less than three in a thousand.

In view of statistics like these, it becomes clear that Edwin Chadwick and his compeers among the sanitary authorities have in half a century done far more to reduce the rate of disease and death than has been done in fifteen hundred years by all the fetiches which theological reasoning could devise or ecclesiastical power enforce.

Not less striking has been the history of hygiene in France; thanks to the decline of theological control over the universities, to the abolition of monasteries, and to such labors in hygienic research and improvement as those of a succession of men like Tardieu, Levy, and Bouchardat, a wondrous change has been wrought in public health. Statistics carefully kept show that the mean length of human life has been remarkably increased. In the eighteenth century it was but twenty-three years; from 1825 to 1830 it was thirty-two years and eight months; and since 1864, thirty-seven years and six months. The question may come up here whether this progress has been purchased at any

real sacrifice of religion in its highest sense. One piece of recent history enables us to answer this question. The Second Empire in France had its head in Napoleon III, a noted Voltairean. At the climax of his power he determined to erect an Academy of Music, which should be the noblest building of its kind in the world. It was projected on a scale never before known, at least in modern times, and carried on for years, millions being lavished upon it. But at the same time the emperor determined to rebuild the Hôtel-Dieu, the great Paris hospital; this, too, was projected on a greater scale than anything of the kind ever before known, and also required millions. In the erection of these two buildings the emperor's determination was distinctly made known, that with the highest provision for intellectual enjoyment there should be a similar provision, and moving on parallel lines with it, for the relief of human suffering. This plan was carried out to the letter; the Palace of the Opera and the Hôtel-Dieu went on with equal steps, and the former was not allowed to be finished before the latter. Among all the "most Christian kings" of the house of Bourbon who had preceded him for five hundred years, history shows no such obedience to the religious and moral sense of the nation. Catharine de' Medici and her sons, plunging the nation into the great wars of religion, never showed any such feeling; Louis XIV, revoking the edict of Nantes for the glory of God, and bringing the nation to sorrow for hundreds of years, never dreamed of making the construction of his palaces and public buildings wait upon the demands of charity; Louis XV, so subservient to the Church in all things, never betrayed the slightest consciousness that while making enormous expenditures to gratify his own and the national vanity, he ought to carry on works, *pari passu*, for charity. Nor did the French nation, at those periods when it was most largely under the control of theological considerations, seem to have any inkling of the idea that nation or monarch should make provision for relief from human suffering, to justify provision for the sumptuous enjoyment of art: it was reserved for the second half of the nineteenth century to develop this feeling so strongly, though quietly, that Napoleon III, notoriously an unbeliever in all orthodoxy, was obliged to recognize it and to set this great example.

Nor has the recent history of the United States been less fruitful in lessons. Yellow fever, which formerly swept not only Southern cities but even New York and Philadelphia, has now been almost entirely warded off. Such epidemics as that in Memphis a few years since, and the immunity of the city from such visitations since its sanitary condition was changed by Mr. Waring, are a most striking object-lesson to the whole country. Cholera, which again and again swept the country, has ceased to

be feared by the public at large. Typhus fever, once so deadly, is now rarely heard of. Curious is it to find that some of the diseases which in the olden time swept off myriads on myriads in every country, now cause fewer deaths than some diseases thought of little account, and for the cure of which, therefore, people rely to their cost on quackery instead of medical science.

This development of sanitary science and hygiene in the United States has been coincident with a marked change in the attitude of the American pulpit as regards the theory of disease. In this country, as in others, down to a period within living memory, deaths due to want of sanitary precautions were constantly dwelt upon in funeral sermons as "results of national sin," or as "inscrutable Providences." That view has mainly passed away among the clergy of the more enlightened parts of the country, and we now find them, as a rule, active in spreading useful ideas as to the prevention of disease; the religious press has been especially faithful in this respect, carrying to every household more just ideas of sanitary precautions and hygienic living.

In summing up the whole subject, we see in this field another of those great triumphs of scientific modes of thought which are gradually doing so much to evolve in the world a religion which shall be more and more worthy of the goodness of God and of the destiny of man.*

MR. GRUM GRZIMAILO has brought four specimens of the wild horse (*Equus Prejevalsky*) home to St. Petersburg from central Asia. He has found that a part of the oasis of Turfan is below the level of the sea, and believes that it represents the bottom of a former lake of considerable extent.

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* On the improvement in sanitation in London and elsewhere in the north of Europe, see the editorial and Report of the Conference on Sanitation at Brighton, given in the London Times of August 27, 1888. For the best authorities on the general subject in England, see Sir John Simon on English Sanitary Institutions, 1890; also his published Health Reports for 1887, cited in the Edinburgh Review for January, 1891. See also Parkes's Hygiene, *passim*. For the great increase of the mean length of life in France under better hygienic conditions, see Rambaud, La Civilisation contemporaine en France, p. 682. For the approach to depopulation at Memphis, under the cesspool system in 1878, see Parkes, Hygiene, American appendix, p. 397. For the facts brought out in the investigation of the departments of the city of New York, by the Committee of the State Senate, see New York Senate documents for 1865. For decrease of death-rate in New York city under the new Board of Health, beginning in 1866, and especially among children, see Buck, Hygiene and Popular Health, New York, 1879, vol. ii, p. 575; and for wise remarks on religious duties during pestilence, see ibid., vol. ii, p. 579. For a contrast between the old and new ideas regarding pestilences, see Charles Kingsley in Fraser's Magazine, lviii, 134; also the sermon of Dr. Burns in 1875 at the Cathedral of Glasgow, before the Social Science Congress. For a particularly bright and valuable statement of the triumphs of modern sanitation, see Mrs. Plunkett's article in THE POPULAR SCIENCE MONTHLY for June, 1891

GLASS-MAKING.

V.—GLASS IN SCIENCE.

By C. HANFORD HENDERSON,

PROFESSOR OF PHYSICS AND CHEMISTRY IN THE PHILADELPHIA MANUAL TRAINING SCHOOL.

WHEN we compare the modern man, the product of many centuries of more or less continuous culture, with the men of ancient Rome, and still more with the men of ancient Greece, the impression unwillingly forces itself upon us that man has somewhat deteriorated since the days of Carthage and Thermopylæ. The reflection is a discouraging one. But observe how unavoidable it is. The modern man can not run so far or so fast, can not see so well, hear so acutely, or speak so loud. All his direct physical powers have suffered diminution. If the comparison be extended to the intellectual world, it is clearly manifest that the loss of power in one direction has not been compensated by the gain in another. One need have no great turn for Hellenism to perceive that the average American, despite his boasting, appears but a struggling child beside the heroes of either the Olympian games or the Athenian groves.

The effect of such a comparison as this is to make one question the truth of human evolution, and to ask himself in all seriousness whether the history of the race is not one of retrogression rather than of advance. But there is another way of looking at the matter, and there are other factors which must needs be taken into consideration.

The suggestion, I believe, is due to Mr. Spencer that, in attempting to measure man's physical power, the summary should not be limited to his direct faculties, but should justly include the acquisitions gained through the exercise of his intelligence. Thus, while it is perfectly true that modern legs are not so sturdy as Grecian legs, it must not be forgotten that by means of steamer and railway the modern man can girdle the earth in a couple of months, and can travel almost unlimited distances at the rate of fifty miles an hour. At the present moment popular lecturers are demonstrating that there is no reason why he should not go two and a half miles a minute. Since this facility of movement is the product of his own increasing development, we must admit that a longer view establishes an increased power of locomotion in the history of the race, and that even here evolution has been constant. The modern vision is faulty and astigmatic. We are veritable bats compared to the men of antiquity, or even to the modern American Indian. But here, again, the brain has more than compensated the defects of the eye. By means of the micro-

scope we see a world completely hidden from the more powerful eyesight of antiquity. By means of the telescope we study a multitude of distant worlds about which the Indian can not even speculate.

Stentor lived on the banks of the Bosporus, not in a busy American seaport. The modern Stentor, with less perfect throat and lung and ear, speaks through telegraph and telephone across oceans and continents; and, in the phonograph, talks without regard to time or place.

One's first impression, then, of man's decrepitude must needs be modified. The evolution of power in matters purely physical is undeniable. In spite of this increase of power, however, the modern man is in many ways a poor creature and unlovable. It is an increase of power by deputy. With his narrow chest, dull ears, near-sighted eyes, and squeaky voice, even his multitudinous apparatus fails to make him comparable with the glorious creature who represented the best product of Greek culture. If our reflection ended here, even Mr. Spencer's very clever suggestion would scarcely make us thankful for an evolutionary process which had given us such doubtful progress. There has been an unquestionable falling off of personal power. The advance has been of the race. But we may believe without undue optimism that this failure of the individual will be but temporary. It is a period of acquisition. We may reasonably hope that this will be followed by a period of expenditure, when the gains of the race will be utilized. To-day, the majority busies itself with the means of living; to-morrow, it may find time to live. The faculties have been sacrificed to the demands of research and mental activity. When these have yielded their harvest, we may look for a wholesome reaction upon the faculties themselves. The knowledge which cost a human life, once gained, will serve a thousand lives. The philosopher whose bent form and bleared eyes bespeak research will be succeeded by a more beautiful generation who utilize his discoveries. Any smaller result would hardly justify the current martyrdom. The coming renaissance will be in the fine art of living.

In this evolution, the materials acted upon have ceased to be simply flesh and blood. The human activity is largely cerebral, while its materials are inanimate. To supply them the three kingdoms of Nature have been ransacked. It is the purpose of the present paper to indicate in a measure the contributions which glass has made to this evolutionary process, for its office is one of increasing importance. In the search for power, the qualities which have given glass so large a value are those particularly of refraction and transparency. These qualities, combined with its hardness and indifference to most chemical

reagents, make it one of the most useful of servants in the good cause of science.

First, then, a word in regard to its refractive power.

If a beam of light pass from one medium to another of different density, such as from air to water, its course is not altered, provided the surfaces of the two media be at right angles to the beam. A penny placed in a basin of water looks in no way distorted if the eye be directly above the coin. But when a beam of light passes into a second medium at other than a right angle its course is bent. A straight stick, partly immersed in water, looks crooked because the light reflected from the portion beneath the water is bent on entering the air. The fact is familiar to every one. This bending of the light has received the name of refraction, and its laws are exceedingly simple. If the beam pass into a denser medium, as from air into water, the bending is *toward* the perpendicular to the common surface of the two media. On the other hand, if the passage be into a rarer medium, as from water into air, the beam is bent *away* from the common perpendicular. We may, then, predict in a general way the course of a beam of light when it changes its medium, but in scientific work we must do better than that—we must know the exact course of the beam. This brings us to the second law of refraction, which is quite as simple as the first, but which requires, if one is not mathematically inclined, a trifle more patience for its comprehension. In any angle, if a perpendicular be dropped from any point on one side to the opposite side, the ratio between the perpendicular and the distance of its starting-point from the apex of the angle will evidently be a constant quantity for that angle, wherever the point be taken. This ratio is called the sine of the angle. If one will take the trouble to draw a series of angles from zero to ninety degrees, he will readily see that the value of the sine increases from zero to unity, and that these are its limits.

Now, it is found by experiment that the ratio between the sine of the angle of incidence (the angle which the impinging ray makes with the common perpendicular to the two media) and the sine of the angle of refraction (the angle which the refracted ray makes with the common perpendicular) is a constant quantity. This quantity is known as the index of refraction.

But it may be asked what all this has to do with glass-making. Essayists are prone to talk about evolution and the fourth dimension of space, and many other things which seemingly have no connection with the subject in hand. In this case, however, the wandering is justifiable, for the index of refraction is a constant which must ever be borne in mind by the scientific glass-worker, if he wishes to use the material in the construction of optical in-

struments. In general, the greater the index of refraction, the more available the glass. The practical question with him is to know the conditions which affect the index of refraction. To answer this intelligently, one must consider why the light is bent at all in changing its medium. If a bather run down a smooth, hard beach into the water, he is very apt to fall head foremost when he reaches the denser medium. His feet are suddenly retarded, while his body keeps on through the air with the old velocity. The result is a change of direction in his motion, which is in one sense disastrous.

Precisely the same thing happens to the light. It is generally conceded to be a progressive wave-motion. When the beam passes into a denser medium at an angle, the side of the beam which enters first is retarded, while the other side keeps on at the old velocity. The result is, that the whole beam is swung out of line and takes a new direction in the new medium. The index of refraction is simply a quantitative expression for this bending, and depends upon the nature of the substance and its density. The great brilliancy of the diamond is due to its very high refractive index, and the sparkle of cut glass is the result of a similar property.

Since the employment of glass in optics depends upon its ability to bend the rays of light to a common point or focus, its value increases with its refractive power—that is to say, with its density. The problem set before the maker of optical glass is, therefore, quite different from that which must be solved by the manufacturer of more every-day goods. He must produce a glass which has great weight without any loss of transparency. The difficulty lies in this, that the substances which add weight to the glass are prejudicial to its transparency. Success is found in the nice balance between these opposing tendencies.

Glass is a double silicate. If it is to have large density, the metallic bases combined with the silica must be heavy. Hence, the ordinary glass of commerce—a double silicate of lime and soda—will not serve in optics. In place of this, a double silicate of lead and potash must be used. The lead gives density to the glass, and consequently high refractive power. The crude materials must be as pure as practicable. To about a hundred parts of sand there is added a mixture of one hundred parts of minium, or red lead, and thirty parts of potash. When these are fused together in large, hooded crucible pots, a very liquid glass results. It is considerably more fusible than the lime-soda glass. So far, the process is easy; but the silicate of lead is so much heavier than the silicate of potash that when the fused mass is allowed to cool the denser silicate has a decided tendency to separate out at the bottom of the crucible. This makes the glass streaky and

quite unfit for use. To avoid this settling and secure a clear, homogeneous glass, that is the problem.

At the present time the best optical glass is probably made in France, and the methods there in use are consequently most worthy of examination. During the melting process the crucible is placed in the center of a domed furnace. The flames play around the crucible on all sides, making an intense heat possible. The hood prevents the furnace gases from acting upon the compounds of lead and reducing them to the metallic state. The well-mixed batch is introduced in small quantities into the thoroughly heated crucible, and the charging process continued until the pot is completely filled. This will require from six to ten hours. The heat is then continued for perhaps four hours, at the end of which time the molten glass is vigorously stirred with a wrought-iron rod incased in a fire-clay cylinder.

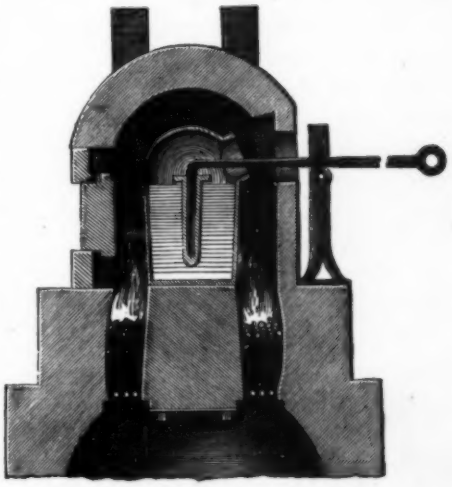

FIG. 1.—FLINT-GLASS FURNACE.

Then comes a second period of quiet heating and a second stirring. After this the stirrings succeed each other at every hour. When these hourly stirrings have been repeated perhaps half a dozen times, the crucible is allowed to cool down for a couple of hours. It is then heated to the utmost that the furnace will permit. As the result of this intermittent treatment, the glass is very liquid and is quite free from bubbles and striations. During the gradual cooling which succeeds this firing, a constant stirring is maintained for at least a couple of hours. When the stirring becomes too difficult, it is discontinued, and crucible and furnace are allowed to cool during a period of ten days or more.

The secret of making fine optical glass lies in this stirring. It was first carried out by Guinand, in Switzerland, in the early part of the century, and was introduced in Paris by Bontemps.

When the cooling is accomplished, the crucible is removed from the furnace and broken, so as to free the mass of flint glass which it incloses. In spite of all this care, it must not be supposed that a mass of perfect glass is the result. On the contrary, it is full of flaws and imperfections, and only a part of it can be used. It is customary to grind and polish parallel faces on the

side of the mass, so that its defects may be located and the perfect portions utilized to the best advantage. The mass is cut into slabs suitable for working up into prisms, lenses, and other optical instruments.

When a large disk is to be made, such as the great lens of a refracting astronomical telescope, several attempts are frequently necessary before success is gained. Two or even three years may pass before suitable material is cast.

As the result of this very troublesome process, we have slabs of fairly homogeneous glass from 3·4 to 3·6 times as heavy as water. Although the greater density is about equal to that of the diamond, the refractive indices of the two substances are not the same. That of the diamond is 2·5 and of the flint glass 1·61. But even this refractive power is the key to many mysteries. The trouble of producing the material counts as nothing in face of the results.

The possibility of increasing the refractive index of optical glass by increasing the density early attracted the attention of experimenters. Since the beginning of the century attempts have been made in this direction. By the use of the heavier rare metals, such as thallium, a glass has been produced over five times as heavy as water. The material has served admirably for the manufacture of artificial jewels, but has not as yet found permanent application in science.

The refractive power of glass, by which the rays of light are bent out of their course and images of objects formed, has its disadvantages as well as its merits. It is almost impossible to construct a lens which shall converge the rays of light without, at the same time, producing rainbow colors around the image. This defect is called chromatic aberration, and, as one can readily see, is fatal to the definition of the lens. It is commonly overcome by employing a compound lens, made of flint and crown glass. The different refractive indices of the materials correct each other's aberration and produce white light. A lens so constructed is termed achromatic, since it does away with the fringe of color. Loss of power is naturally the price of such a correction. These difficulties led to the project of making lenses out of a material which should obviate the color fringe by something in the glass itself. It is found that titanic and boric acids have a marked effect upon the refraction of the differently colored rays, and compounds of these materials have been used to good purpose. We have here a field well worth further exploration.

The best flint glass for optical use is made in Europe. It is an interesting circumstance that the great establishments of Messrs. Chance and Company, at Birmingham, and M. Feil et Cie.—now M. Mantois—at Paris, which largely supply the Ameri-

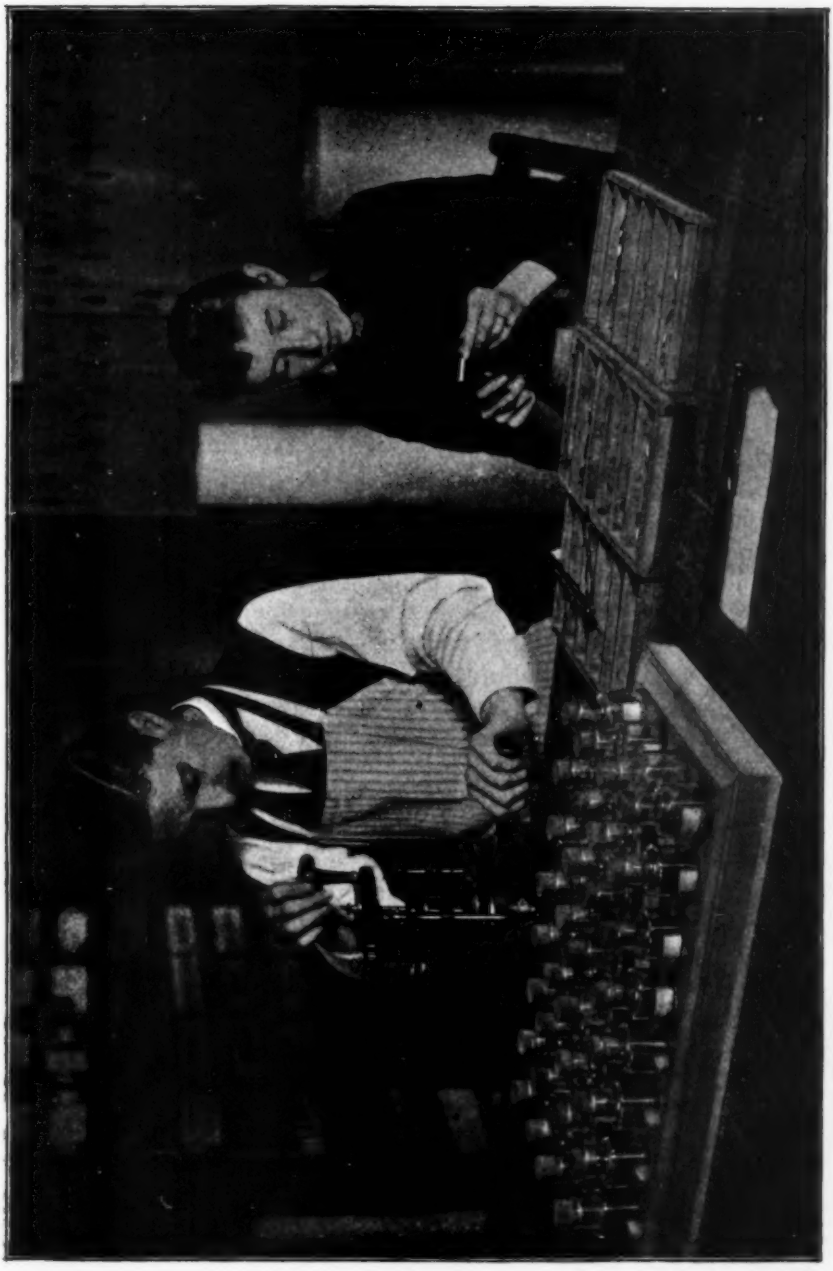

FIG. 2.—MAKING SPECTACLE-LENSES.

can market, are both, in this department at least, lineal descendants of the persevering Swiss watchmaker, Guinand, to whom we owe the present superiority of optical glass. The material is imported in convenient slabs for use in smaller articles and in rough disks for the larger lenses.

A noted French critic has left on record a touching account of the first time he ever looked through a pair of spectacles. He was terribly near-sighted, but no one had ever given sufficient attention to the defect to make any attempt to remedy it. One day, while still a boy, he got hold of his grandfather's spectacles, and put them on. Great was his surprise to find that the giant tree which shaded his play-ground was made up of individual and beautifully formed leaves instead of being, as he had previously supposed, one almost solid mass of green foliage. The boy fairly danced with delight, for a new world was suddenly opened to him.

A little fragment of glass, which thus gives sight to the almost blind, must claim attention even before the instrument which discloses either microcosm or macrocosm, for it has to do with the most important of all sciences, the science of daily living. The grinding of the small lenses for spectacles and eye-glasses is carried on in many establishments throughout the country and has been reduced to very accurate practice. Three surfaces are utilized—spherical curves, cylindrical curves, and prismatic faces. Their effect can readily be understood if one will consider for a moment the passage of a beam of light through an ordinary triangular prism. As the light is bent toward the common perpendicular on entering the glass, and away from the common perpendicular on leaving the glass, the total bending will be toward the base, or thicker portion. Now a lens may be considered a double prism; convex, if the two prisms be placed base to base, and concave if they be apex to apex. Since the light is always bent toward the thicker portion, the convex lenses converge the rays while the concave ones disperse them. In designing lenses for spectacles, these principles find application. If the eye be perfectly formed, but have too little or too great convexity, the remedy is found in glasses with simple spherical faces; but if the structure of the eye be faulty and non-symmetrical, as in the astigmatic, the glasses must have cylindrical or prismatic surfaces.

The bit of glass to be formed into a lens is fastened by means of pitch to a small block of hard rubber so that it may be more readily handled. It is ground by being pressed against a rapidly revolving metal tool, whose curvature is equal and opposite to that desired in the lens. This is known as the "rough tool" and is made of cast iron. It is mounted on a vertical spindle, and is kept moistened with emery and water. Several grades of emery are used in succession, changing from coarse to fine as the grinding proceeds. As a result of this process the glass has a rough surface and is no longer transparent. It is now transferred to the "fine tool." This is made of brass and has its surface as true

as possible. It is compared from time to time with a standard curve, in order to insure accuracy. In this second grinding the abrading material is rouge (carefully calcined sulphate of iron). Finally, the lens is polished by being pressed against a piece of cloth powdered with rouge and fastened to the rotating tool. The glass is now loosened from its block, turned over, and the reverse side of the lens ground. When this has been accomplished, the lens must be cut down to the proper shape for mounting in the spectacle-frame. It is placed on a leather cushion and held firmly in position by a rubber-tipped arm, while a diamond glass-cutter passing around an oval guide traces a similar oval on the glass below. The superfluous glass outside of the oval is removed by steel pincers, the rough edges are ground smooth on Scotch wheels, and the lens is ready for mounting. The glasses for small telescopes, microscopes, burning-glasses, and the like are ground in the same fashion.

When, however, it comes to grinding the lens for a large astronomical telescope, the process is slightly modified. The work is one requiring considerable skill and patience, though it involves no very great difficulties. It was formerly done entirely by hand and by individual workmen rather than by large firms. It will be remembered that the philosopher Spinoza earned his living by grinding lenses, and since his time less famous workmen have patiently pursued the same trade. At present the grinding of telescope lenses has assumed the proportions of a business, and has nowhere been carried to greater perfection than in America. The firm of Messrs. Alvan Clark and Sons, whose workshops are at Cambridgeport, Mass., have gained a reputation which extends on both sides of the Atlantic, as their lenses exceed in both quality and size even the best products of European skill. A great astronomical telescope is indeed quite cosmopolitan in its genesis. The glass is cast in Paris, the grinding is done in Massachusetts, the mountings are made in London or Berlin, and the telescope itself is pointed toward the heavens from Mount Hamilton or from the Russian Imperial Observatory at Pulkowa.

All the glass ground at Cambridgeport comes from the establishment of M. Mantois in Paris. It is imported in the shape of large disks, which are generally flat on both sides. The first grinding is done by machinery, the abrading material being Tilghman's chilled iron globules. These are found to be more effective than sand. The finer grinding is accomplished by means of varying grades of emery. It is in the finishing process that the American operations take rank over the foreign. The final touches and the polishing are all done by hand, the rouge being applied on the tip of the finger. It is necessary to employ constant tests during the course of the grinding. At first, these

are all mechanical and are made with a spherometer. Such tests, however, simply insure accurate curvature, and by their very nature can take no account of irregularities in the texture of the glass. These can only be detected and remedied by means of optical tests. When the preliminary polishing is finished, the lens

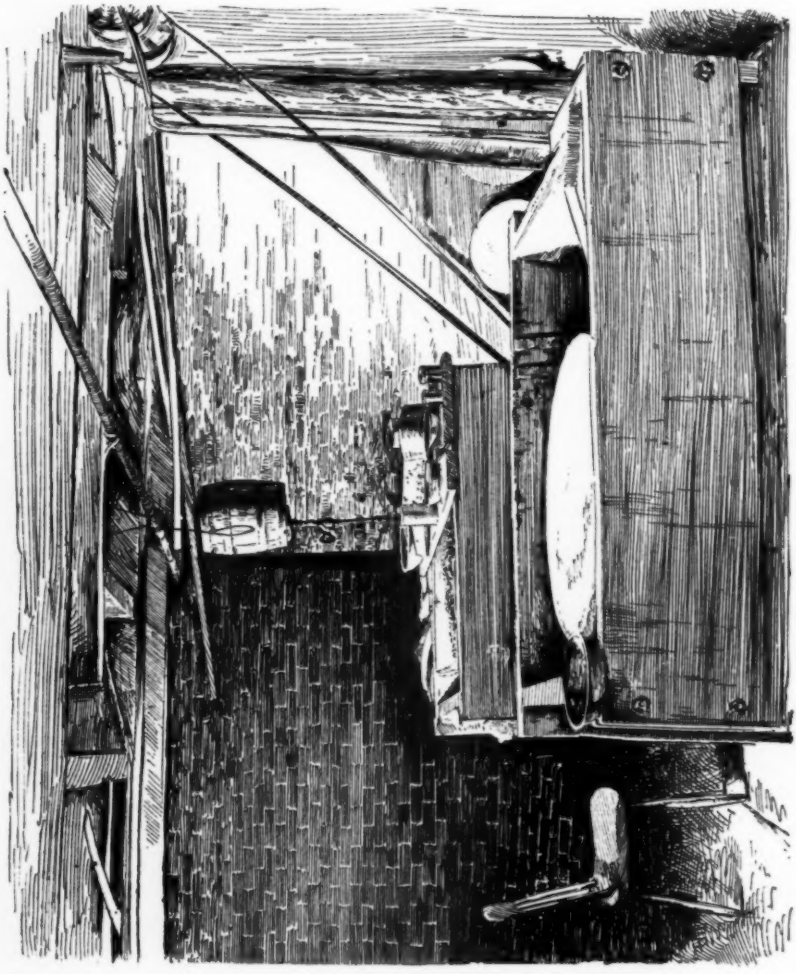

FIG. 3.—GRINDING TELESCOPE-LENSES.

is roughly mounted and submitted to a most rigid examination. A beam of light from what is called at the workshops an "artificial star" is transmitted through the lens and enables the workmen to locate defects of all sorts. The remedy is then a matter of touch and try, and, as one can readily imagine, is a long and tedious process. Still, the lens is not completed. It must now be submitted to the test of actual star-gazing. The most famous lens turned out by the Messrs. Clark, and indeed the largest in

existence, is the one now mounted in the Lick Observatory in California. It has an aperture of thirty-six inches in the clear. It was tested on seventy different nights, on veritable stars, before it was considered finished. It sometimes happens that important astronomical work is done with these temporarily mounted lenses, and some of them have quite a history. Thus, in *ante-bellum* days, an eighteen-inch objective was ground for the University of Mississippi, but, the war coming on, the lens was never sent for. It was afterward used at Chicago, and is now doing good work at Evanston, Ill. While it was temporarily mounted at Cambridgeport, Mr. Alvan G. Clark discovered the companion to the dog-star Sirius, a discovery for which he was awarded the Laland prize by the Imperial Academy of Paris. At the present time a twenty-inch objective for the University of Denver is in progress, while a forty-inch disk of crown glass awaits transformation into a lens for the University of Southern California. It was at first feared that such giant lenses would suffer injury by warping, but the experience at Mount Hamilton has been so reassuring that the present tendency is toward even larger glasses.

It would still be a difficult task, though a less difficult one than the present, if it were simply required to produce a perfect curvature, but the superiority of a lens depends upon its chemical composition as well as upon its geometric form. The problem may be summed up by stating that one must have as homogeneous a material as possible, to start with, and as symmetrical a form as the inequalities in the material will permit, to end with, the theoretical curves being in practice slightly modified to obviate any small irregularities in density.

The crown-glass lens with which the flint glass is combined in order to obtain achromatism is made in the same way, only that the material is a lime-soda silicate similar to that used in window glass instead of having lead and potash as its bases.

It would be easy to multiply illustrations of the use which science makes of the refractive power of glass, as in the stereopticon, the kaleidoscope, the camera, the projecting lantern, and in other apparatus of scientific or popular nature; but in the manufacture of all of them these two principles hold—the production of a heavy, uniform glass, and the shaping of this material into suitable form by processes of grinding and polishing.

There is, however, one application so important to philosophic thinking as to deserve special mention, even though it involves no new principle. What the astronomical telescope has been in the study of the physical features of the heavenly bodies, the glass prism is in the investigation of their chemical constitution. Had one spoken but a few years ago about the chemistry of the sun and stars, and seriously proposed their analysis, his hearers

would probably have tapped their foreheads significantly and perhaps even winked at one another. But to-day stellar chemistry is a recognized branch of cosmical research. If a ray of sunlight be passed through a glass prism, it gives a bright, continuous spectrum, varying in color from red to violet. If the source of light be a vapor of a metal, or metallic salt, the continuous spectrum is replaced by one or several bright lines whose position and color are invariable for the same metal. If a more intense white light be allowed to pass through the metallic vapor, the former bright lines appear black, but are easily recognized by their number and position. In the solar spectrum a whole series of such black lines are distinguishable, and by correspondence they are believed to indicate the presence of at least seventeen of our earth elements, while there appears to be at least one element in the solar atmosphere for which we have no counterpart on earth. A similar study of the light of the stars has disclosed in their atmosphere a number of earth elements and has indicated the presence of others unknown on earth. This little piece of flint glass, ground into the shape of a triangular prism, has proved the "open sesame" to secrets so profound that in its absence they must have been regarded as belonging to the great domain of the unknowable. It is something of a triumph for the near-sighted philosopher on our planet to announce that he has discovered magnesium on the star Aldebaran and sodium on Sirius.

While the refractive power of glass opens so many wonderful possibilities, its simple transparency is a quality which adapts it for many less ambitious uses. Much of the work of science is that of measurement. Sir William Thomson has indeed said that in any branch of research we have only so much science as we have mathematics. For this service of measurement, glass is admirably adapted. The measurement of heat by the thermometer is an example of a frequent and important operation, while the manufacture of the instrument itself is a type of many similar processes.

The ordinary thermometer measures heat by the expansion of some such liquid as mercury. The increase in bulk for any slight increment of heat would be too small, however, to be perceptible in a mass of the fluid metal. Hence the necessity for the glass-blower's skill by which the increased volume is made sensible to the eye. By having a comparatively large bulb in connection with a tube of very fine bore, the slightest expansion in the volume of the mercury becomes at once apparent by a relatively large change of level of the fluid in the tube. The greater the discrepancy between the bulb and the tube, the more sensitive the instrument.

The operation of making a thermometer begins in the crucible-

pot. The glass-blower dips his blowpipe into the molten mass of glass, withdrawing a small quantity of the material with his pipe. The plastic mass is rolled into a pear-shaped ball on the marvering table. A little air is then blown into the center of the

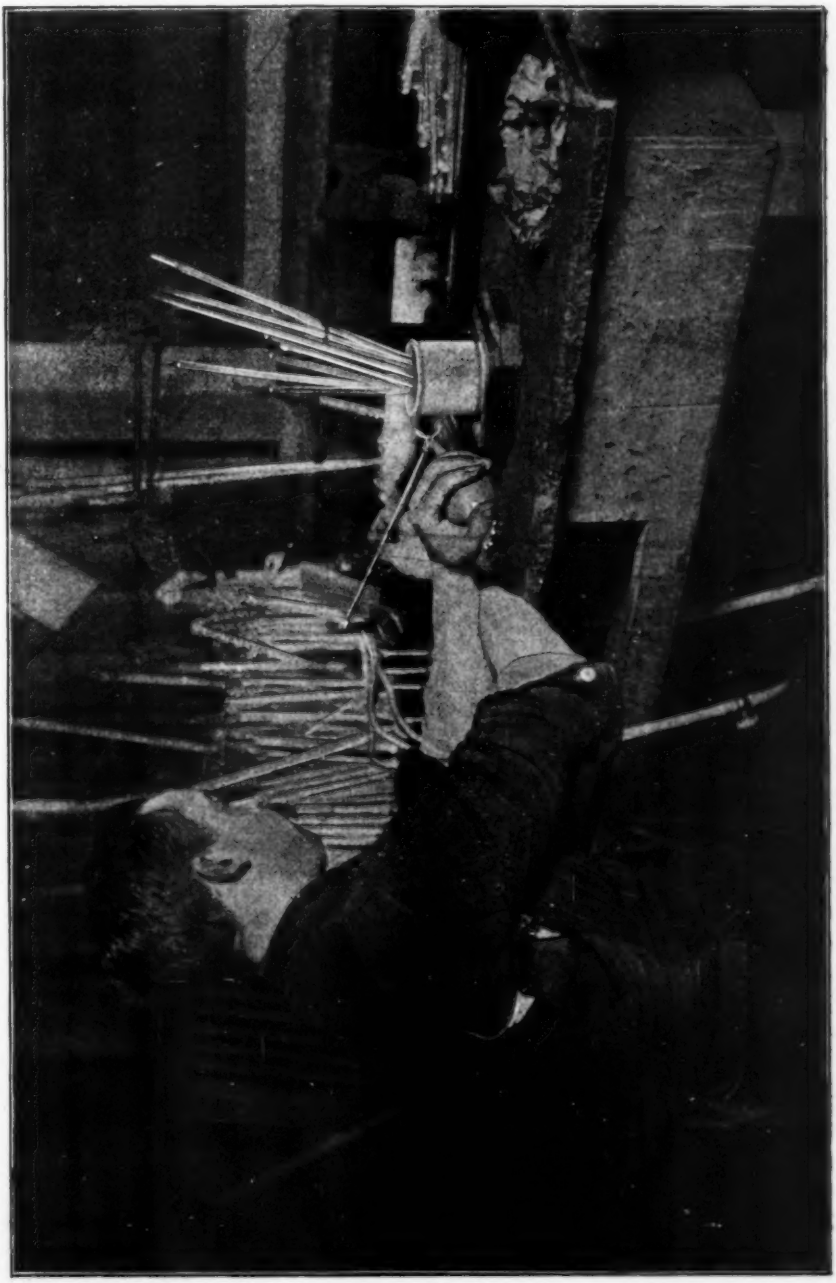

FIG. 4.—BLOWING THERMOMETER-BULBS.

mass, and a second workman attaches the end of his iron rod or "punty" to the free end of the ball. The blower remains stationary, while the second man walks away from him, carrying his punty with him. In this way the mass of glass is drawn into a long tube, perhaps fifty feet long, the bubble of air preserving a fine opening throughout the entire length of the tube. In the better thermometers, the tube is somewhat flattened, so as to make the thread of mercury more visible, and a background of opaque white glass is added for the same purpose. These modifications are made more easily, perhaps, than one would imagine. By flattening the ball of glass before it is drawn into a tube, the elliptical cross-section is secured, while a string of opaque glass welded on to the still plastic ball becomes elongated into a thin plating on one side of the tube.

It is impossible in this way to secure tubes of absolutely uniform bore, but the inequalities are much less than one would suppose. For ordinary instruments the variation may be neglected. The tubes are then cut into convenient length and sent to the workshop of the thermometer-maker. One can readily pass a whole morning in the little room where he works, for there is a certain interest attaching to so individual a task as this which is not found in more wholesale production. The instrument-maker sits on a high stool before his work-table, his principal tool being a conveniently arranged blowpipe. This is not the hand and mouth tool used by mineralogists and jewelers, but is a permanent blowpipe fed by gas and operated by a blast of air.

The first operation is that of forming the bulb. In the better instruments this is made out of a separate piece of glass and is then attached to the tube. In this case the bulb is made cylindrical in form, so as to afford large capacity without too great diameter. In the less expensive thermometers, the bulb is formed directly on the end of the tube itself. The glass is first fused in the blowpipe flame until the end is entirely sealed. A short rubber hose with a small rubber ball on the opposite end is then slipped over the open end of the thermometer-tube. The sealed end of the tube is again softened before the blowpipe, and then, by simply pressing the rubber ball, the air forces the plastic glass into a symmetrical bulb. It is a pretty little operation, for the glass responds so delicately to the thought of the workman.

It is found that glass undergoes a slow contraction during a period of two or three years, and, where great accuracy is desired, the tube must be put away for that time to season.

The bulb and tube are now to be filled with mercury. The tube is much too fine to allow the mercury simply to be poured into the bulb. Indirect means must be used. The open end of the tube is softened and quickly blown into a large bulb, while

the end is drawn into a fine jet. This is hastily plunged beneath the surface of a bath of pure mercury while the whole thermometer is still hot. As it cools, the air inside shrinks and the mercury

FIG. 5.—CALIBRATING THERMOMETERS.

rises into the outer bulb. The permanent bulb is then carefully warmed, the tube being in a horizontal position so that the expanding air may freely escape. The tube is then held vertically

and allowed to cool. The mercury in this position closes the upper end of the tube, and as the cooling proceeds it is sucked through the capillary opening and falls, drop by drop, into the bulb below. The process is repeated, if necessary, until the lower bulb is filled with mercury. The thermometer is then heated. The mercury expands, driving out all the air and filling both bulb and tube. The temporary bulb is now removed, and the open end of the tube is closed before the blowpipe. The thermometer is ready for calibration.

The bulb is buried in cracked ice, from which the water is allowed free drainage. When the mercury no longer contracts, a mark is made on the tube at a level with the mercury. This is the freezing-point of water, 0° on the centigrade scale, or 32° on the Fahrenheit. Réaumur's scale, with the freezing-point at 0° and the boiling-point at 80°, although so extensively used in Germany and Russia, is seldom seen in this country. The thermometer is then transferred to a bath of boiling water. The mercury quickly rises, and soon again becomes stationary. The tube is marked for the second time. This is the boiling-point of water, 100° centigrade, or 212° Fahrenheit. As the temperature of the boiling-point varies with the atmospheric pressure, the barometer must be read and a corresponding correction made, or else a standard thermometer must be kept in the bath, and the marking made in harmony with that. These two points determined, the operation of making a thermometer is almost completed. It has now only to be marked.

The tube is dipped into a bath of melted beeswax, and as soon as the thin layer of wax hardens it is taken to the dividing-engine. The space between the freezing and boiling points is here divided off into 100 divisions if the centigrade scale is to be employed, or into 180 divisions if the Fahrenheit be used. Every tenth line is made somewhat longer than the others, and is the only one marked. The marking is done on a machine constructed after the order of a pantograph. The waxed tube is laid on a small sliding platform and secured to its bed by a few drops of melted wax. A sharp stylus is then brought to bear upon the point where the marking is first wanted. The movement of the stylus is controlled by a long lever, whose own movement is, in turn, controlled by the action of a second stylus. This is made to pass over the desired figures cut in brass on a lower platform of the machine. The action of the system of levers is to reduce the motion of the upper stylus, and consequently the size of the figures traced through the wax. In this way accurate marking is secured on a sufficiently small scale. The tube, thus lined and marked, must now be subjected to the action of hydrofluoric acid. A solution of the acid in water, to which some alkaline salt has

been added, is rubbed over the tube. In a few moments the glass is sufficiently bitten. The tube is washed with water and the wax removed. The lines and figures are then blackened with varnish, and the thermometer is ready for use.

It must not be supposed that the same care is employed in the

FIG. 6.—THE DIVIDING-ENGINE.

construction of the ordinary instruments sold in the shops for domestic usage. Their low price would preclude that. They are made in large quantities, and their calibration is only approximate. They have been known to be as much as six or eight degrees out of the way; but that is much worse than the average. After one has watched the construction of a scientific thermometer, he wonders not that they should cost a couple of dollars or more, but rather that they can be sold at such a price.

For many purposes, such as the systematic observation of the weather, it is desirable to have thermometers which shall register the highest and lowest temperature reached. These maximum and minimum instruments require additional care on the part of the thermometer-maker. In the latest pattern manufactured for the Signal Service a decided improvement has been made in the self-registering device for maximum temperatures. The bore of the tube is greatly contracted at a point somewhat below the lowest reading that will probably be required, and the thermometer is usually placed in a horizontal position. Under the action of an increasing temperature, the mercury expands and forces itself through the very narrow opening. But when the temperature falls, the mercury will not pass through this opening, and all the shrinkage of the fluid in the bulb takes place below the contraction. As a consequence, the column of mercury remains stationary, and so records the highest temperature reached. By vigorous shaking the instrument is readily reset.

In the thermometer for registering the lowest temperature colored alcohol replaces mercury. A little rider of glass is so trimmed with fine hairs at each end that, while it does not fit in the tube with sufficient snugness to prevent its being pushed down the tube by the retreating meniscus at the surface of the alcohol, it will become wedged in place when the column ascends.

The special feature to be noticed in the manufacture of the thermometer is the individuality of the process. Each instrument is the subject of a separate operation. The same principle is applied in the manufacture of barometers and hydrometers. In the fabrication of the first, a glass tube is simply closed at one end and then filled with pure mercury, from which all the air has been expelled by boiling. Its subsequent marking and adjustment in a suitable frame are only matters of careful handling.

In the fabrication of hydrometers more special work comes in. The transparency of the material is not here an essential feature, although it is utilized and the graduation placed inside of the tube. The quality which renders glass particularly available for this service is its indifference to chemical reagents and its constant weight. The principle upon which hydrometers are constructed is familiar to all. In order that an object may float,

it must displace its own weight of the supporting fluid. If, then, a float of invariable weight be immersed in a liquid, the depth to which it sinks will be a measure of the specific gravity of the

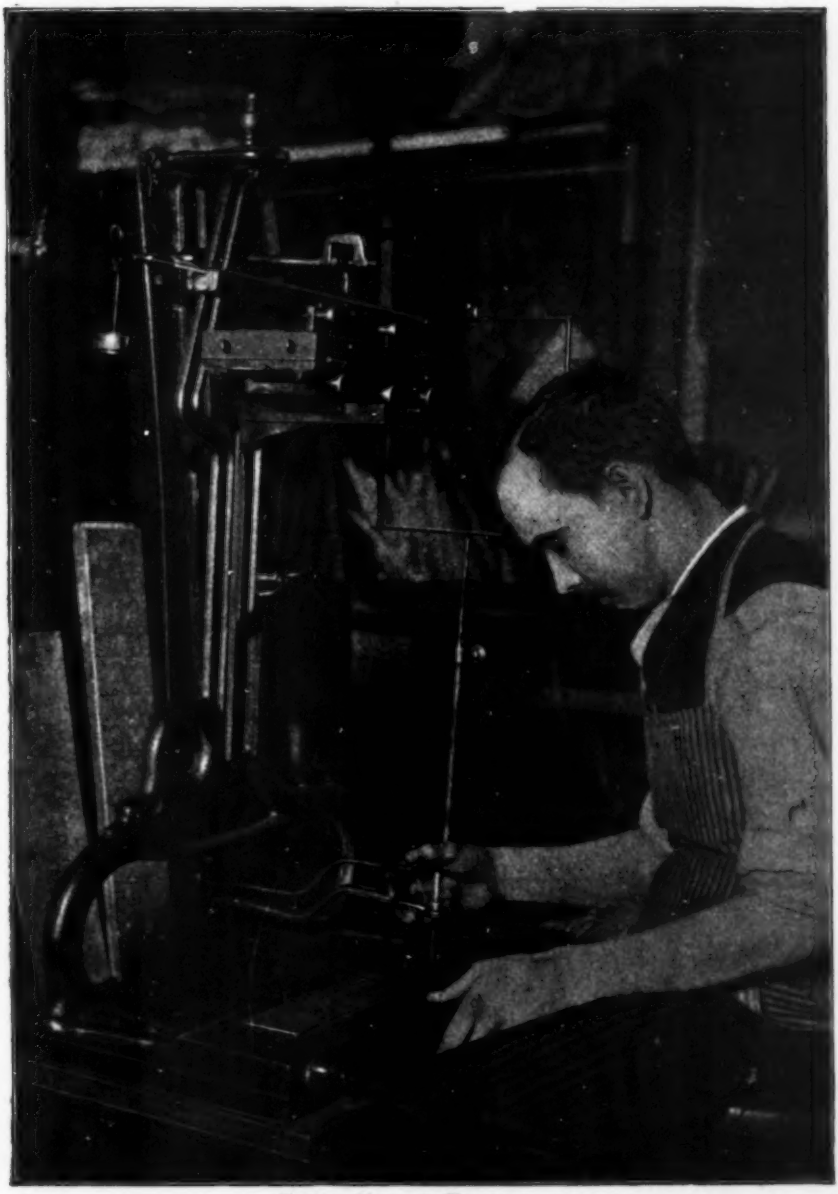

FIG. 7.—MARKING THERMOMETERS.

liquid. The hydrometer is simply such a float as this. It is made in different forms and styles, according to the use for which it is intended; but in all cases it is essentially a cylinder or bulb of

glass, loaded at the bottom with either mercury or shot, and terminating above in a slender, graduated tube. The weight of the metal so lowers the center of gravity that the instrument always floats in a vertical position. A suitable length of plain

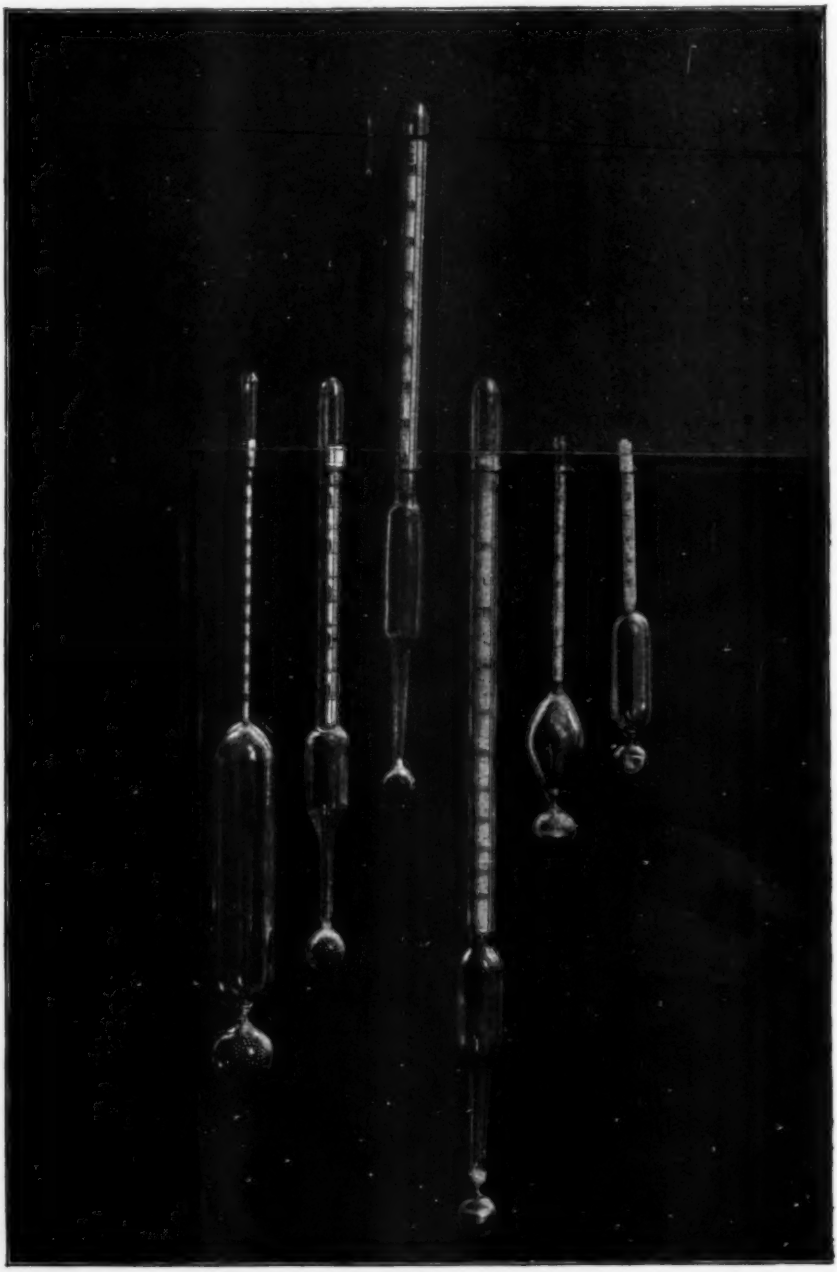

FIG. 8.—VARIOUS FORMS OF HYDROMETERS.

glass tubing is taken by the glass-blower and sealed at one end. A bulb is then formed for the reception of the ballast, and the upper end is drawn out into a smaller tube. Mercury or shot is then added until the instrument floats in an upright position. It is placed in pure distilled water at 60° Fahrenheit. If the hydrometer is to be used for measuring the specific gravity of liquids heavier than water, it is loaded until the level of the water almost reaches the top of the tube. The instrument is then placed in a second heavier liquid of known specific gravity. It will come to rest farther out of the fluid than before, since it must needs displace less in order to float. This second point established, it is easy to construct the scale. If the hydrometer is to be used for liquids lighter than water, let us say for alcohol, it is so loaded that when placed in pure water the level will only reach up to the lower part of the tube. It is then placed in a lighter liquid of known specific gravity. It will sink lower in this case, since it must needs displace more of the fluid in order to float. This second point established, it is an easy matter to continue the graduation upward in space and downward numerically. The scale employed depends upon circumstances. In the direct-reading hydrometers, the point to which the instrument sinks in pure water is marked one, and the other readings express directly the specific gravity of the fluid into which it is plunged. In others, the scale is empirical—that is to say, the degrees bear no relation to actual specific gravities. In certain manufacturing processes such scales are used with the purpose of keeping trade secrets. Where the hydrometer is for a special use, such as measuring the specific gravity of alcohol, it is known as an alcoholometer, and the marking ascends from pure water at the bottom of the graduated tube to pure alcohol at the top. The degrees give at once the percentage of alcohol in the liquid under examination. One of the most familiar special forms is the lactometer, the hydrometer used for measuring the specific gravity of milk. The scale is commonly drawn on a piece of paper which is fastened inside the tube in the right position. The end is then sealed before the blowpipe, and the instrument is ready for use.

The manufacture of pressure-gauges and other glass instruments for measurement proceeds in much the same fashion.

In chemical and physical laboratories the use of glass instruments is a simple necessity. Combustion-tubes, beakers, funnels, test-tubes, watch-crystals, burettes, pipettes, absorption bulbs, bell-jars, flasks, apparatus for electrolytic decompositions, and a hundred other essential articles could scarcely be made of any other material. Here the transparency of the glass, its great strength, and its almost total indifference to the action of reagents give it special suitableness. The principles involved in the manufact-

ure of these objects are simply ingenious modifications of those involved in processes already described. Most of the scientific apparatus in glass is brought from Thuringia. Our own workmen do not seem to have that turn for science which is shown by the Germans. Even the little apparatus which is made in this country is for the most part the work of foreign artisans.

It would be a grave omission to close even so brief a summary of the office served by glass in science without calling attention in a few words to one of the latest and most interesting lines of research which it has made possible. We refer, of course, to the vacuum tubes employed by Mr. Crookes in his well-known investigations into the properties of radiant matter. We have been ac-

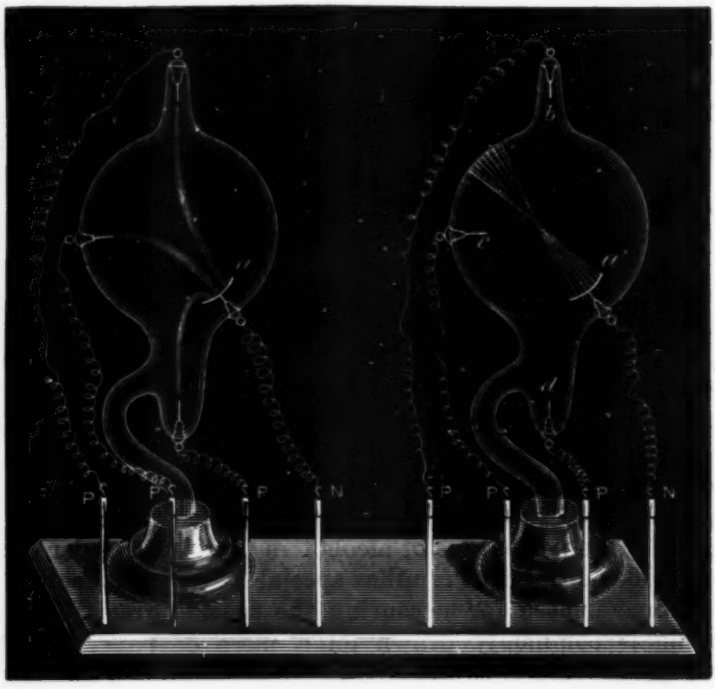

FIG. 9.—VACUUM TUBES.

customed to talk somewhat glibly about the three states of matter. To this list we are now asked to add a fourth, the radiant. Faraday's hint and the work of Mr. Crookes have well-nigh established the distinction between gas and radiant matter. In a gas under ordinary tension the molecules are in sufficient number to suffer almost constant collision with one another; but if the tension be low enough, say the one five-millionth of an atmosphere, the collisions become infrequent, and the molecules travel in almost uninterrupted straight lines until they come into con-

tact with the sides of the containing vessel. For this state of matter the term *radiant* seems at once appropriate and happy, for matter so attenuated exhibits phenomena apparently entitling it to a separate class and name. The radiant-matter tubes are simply bulbs or cylinders of glass several inches long and perhaps three or four inches in diameter, which contain only the most minute traces of gaseous matter. Metallic terminals for electric connection are sealed into the glass. These are given various shapes and positions, so that the behavior of radiant matter under different conditions may be observed. The manufacture of radiant-matter tubes is a work of dexterous glass-blowing. In the simpler forms a plain cylindrical tube is taken as the basis, and is sealed at one end. After the electrodes have been put in place, the other end is drawn into a fine tube, which is also sealed as soon as the exhaustion has been accomplished. Some of these tubes have been made experimentally in this country and more in England, but the home of this industry is also to be found in the Thüringer Wald. They deserve special mention in this connection, since no other material than glass would serve for such investigations.

The philosopher was formerly represented as a seated figure in a gown, and surrounded by hour-glass and old folios. To-day he is more active. He is better pictured in a blouse, and standing, surrounded with the apparatus of science. In his search for power he has brought new material to his service, and none of greater value than that which enables him to study distant globes, to investigate the inner history of an infinitesimal world, to find out the chemistry of the stars, and to pry into the properties and constitution of matter. But he stands there not in pride. The figure is one which breathes a deep humility. Each victory over the unknown only makes him the more sensible of the infinite world beyond his present vision. The office of science is corrective and disciplinary. It teaches one of its deepest lessons when it opens the eyes to the recognition of that which is unseen. The evolution of true power is the evolution of a spiritual insight which, in perceiving the known, perceives also the existence of something beyond. The greatest service of glass lies not in the definite knowledge which it brings us, but rather in the stimulating possibilities which this knowledge suggests.

THE result of Mr. Horatio Hale's examination of the subject, communicated by him to the International Congress of Americanists, is that "so far as our present knowledge extends, the theory that would trace the origin of the population of America, or any portion of it, to the Polynesian race, finds no countenance in the testimony of language, and is made extremely improbable by the very recent appearance of that race in the eastern Pacific islands."

SCHOOLS FOR THE INSANE.

By CHARLES W. PILGRIM, M. D.

THE teaching of the insane is by no means a new idea. Early in the history of the Utica Asylum Dr. Brigham made the experiment of having winter classes, and wrote in his annual report for 1844 of the great advantages resulting therefrom. These classes, however, were not long continued, and, if I mistake not, a like history was enacted in the Northampton Lunatic Asylum, where Dr. Earle, our oldest American alienist, instituted a similar work at about the same time. Dr. Kirkbride, another pioneer in American asylums, advocated the education of the insane; but, instead of having organized schools, he had what were known as "companions," who visited the patients in different wards and gave them instruction by reading and conversation. I know, however, of no single attempt in this direction in any of the American asylums which was at all prolonged, and, with one exception, the result was the same with the experiments which were made from time to time in various parts of Great Britain and the Continent. The exception was the Richmond District Lunatic Asylum in Dublin, where Dr. Lalor's zeal and energy elaborated the idea and made of it such a success that his asylum became known on account of its school to alienists in the most distant parts of the world. In 1885, when the school had been in successful operation for about thirty years, I had the pleasure of spending three days with the venerable old man, who is justly called the "father of the school system." He has since laid down the burden of life, but the system which he inaugurated still lives, and is carried on under the direction of his successor.

At the time of my visit there was a daily average of about four hundred and fifty men, and, as the two departments of the asylum are conducted practically in the same manner, I shall confine myself to a description of the male division and its school. About forty of the four hundred and fifty men were in the hospital ward and took no part in the school exercises. Of the remainder, eighty-five were engaged during the day in the garden and various industrial occupations, but about seventy of them attended school on three evenings in the week for an hour after supper. A little more than a hundred were occupied solely in masonry, farm-work, tailoring, basket-making, shoemaking, etc., and more than two hundred were occupied during the greater part of the day with the school exercises. It will thus be observed that nearly every patient in the asylum, excepting those in the hospital de-

partment who were physically incapacitated, was engaged either in the school or industrial exercises, and that seventy were engaged in both. It is true that quite a number of the patients whom I saw were too demented to take a very active interest in the exercises, but it certainly seemed to me that constant effort in this direction could not fail to produce a beneficial effect by infusing a spirit of order among the patients, even if it did nothing more. Object-teaching was the plan most in favor among the more stupid ones. For instance, a piece of India rubber would be handed to one of the class, the teacher asking him at the same time to name it; he would then ask its color, shape, and qualities, getting the patients, by experiment, to find out that it was tough, smooth, opaque, pliable, etc., finally ending by questions as to its uses. Some other object, as a piece of glass, would then be taken up until the time allotted for the exercise in that particular way was exhausted. On one or two occasions the Irishman's natural wit could not be restrained. As, for instance, when one was asked in regard to the most important uses of glass, he replied, for "making whisky-tumblers, sir"; and another, when asked in regard to another object, said, "Sure, you know, sir, without asking me to tell you." The more advanced pupils were instructed in reading, writing, arithmetic, and geography. Music occupies a most important place in the system, and I was told that, when a patient's attention could not be gained in any other way, it was frequently possible to get him interested in the singing-class, and afterward in the other classes. The singing is accompanied with instrumental music. Even the theory of music is not neglected, a portion of the daily singing half-hour being devoted to practicing the scale. It should be mentioned in this connection that music also exerts an important influence in another direction, as it naturally leads to drilling and marching, and by placing the less active patients here and there in the line even the most inert can be induced to take part in the exercises, and thus obtain an amount of physical training which it would be difficult to give them in any other way. A number of patients also act as monitors, keep records, etc. The object of the school as formulated by Dr. Lalor is, first, to provide occupation for a large class who otherwise would be unemployed; secondly, to vary the occupation of the patients; thirdly, to apply a system of education to the relief of mental disorders; and, fourthly, to promote the happiness and welfare of all the inmates.

I have visited a large number of asylums in various parts of the world, and I am sure that I have never seen any in which there was better discipline and order among the patients. Like all Irish asylums, the wards of the Richmond District Asylum were poorly furnished, and they lacked many of the features

which characterize our sometimes palatial institutions. But, though cheerless in other respects, there were cheap harmonicums even in the most disturbed wards; and, although they were little better than our street hand-organs, it seemed to me that they served a far better purpose than the solitary grand piano which is only seen in the convalescent wards of our State institutions. There were signs of activity everywhere, and a gratifying absence of that gloomy monotony which is so apt to pervade asylum life. The other Irish asylums which I visited were in marked contrast to this; and there was nothing, so far as I could observe, to account for the superiority of the latter, save the school system so energetically pursued.

In proof of the old adage that history repeats itself, the experiment that was tried in the Utica Asylum nearly half a century ago was again taken up some three years since. A similar revival of interest in this subject also took place in two or three other American asylums. In Utica, a small class for the men, with a recovered patient as teacher, was first organized, two hours in the morning being devoted to the teaching of the simpler branches. Such was its success that another class was soon formed for the instruction of the women. The next winter the school was again opened, and it is now in its third year of successful working; and the interest maintained is so great that it is at times difficult to find places in the school-room for all who wish to attend.

The female department of the school (the one to which I shall confine my description) is in charge of an experienced teacher, who is assisted by three patients. Two are melancholiacs who have delusions of a depressing character, and one frequently makes the ward doleful with her moans. The third has the delusion that she is the wife of a prominent physician in a distant part of the State, and insists upon being called by his name. All three, however, manage to keep their delusions in abeyance, and appear to quite forget them while engaged in their work. The population of the women's wards is a little above three hundred, and of this number about seventy are enrolled as members of the school. The average attendance is about fifty. This number could be greatly increased; but, as the school-room is small, only selected cases, and those who are particularly anxious to become pupils, are allowed to attend. The session is held between the hours of ten and twelve in the morning. The teacher first reads a chapter from the Bible, the question of the Bible in the school not being a disputed one in this particular instance; the pupils then repeat the Lord's prayer in unison, and afterward unite in singing one of the gospel songs. The books are not taken from the school-room; the lessons are given out, and about a quarter of an hour is allowed for their preparation.

The school is divided into three sections—advanced, intermediate, and primary. The advanced course consists of geography and historical reading, and is in charge of one of the patients. In the intermediate division, arithmetic as far as percentage, reading, geography, and grammar are taught; it is in charge of two other patients. The primary division, contrary to the general rule, is in charge of the schoolmistress, and the pupils are taught to read, spell, write numbers, and do easy sums. No two in this division are equally advanced, and its successful working requires a large amount of tact and exhaustless patience. At first this department was in charge of the patients, but experience has shown that the pupils get along much better under the more experienced instruction of the head of the school. The pupils range in age from fourteen to seventy-seven. Preference, however, is given to the younger ones who desire to attend, more than half being under forty, nearly one third under thirty, and about one eighth under twenty years of age. They suffer from the various forms of mental trouble, but here again preference is given to those who have melancholia and the more acute forms of insanity. Chronic cases are not excluded, however, and among those who can receive no benefit save the two hours' daily relief from the monotony of asylum life are two Virgin Marys, one queen of the world, one daughter of ex-President Cleveland who is nearly seventy years of age, two who imagine that they have passed from the scenes of earth and dwell among the dead, and one who has the curious delusion that people are constantly walking upon her fingers. As curable cases, and those most likely to recover, are the ones who generally attend the school, the direct curative influences can not be accurately estimated; but, as might be expected, the most encouraging results are met with in the young and in those whose insanity has been of comparatively short duration. I can recall two cases where the patient could not read or write before becoming insane, but became fairly proficient in both before returning home. Three others also occur to me who appeared to be in the depths of dementia, but were, after several days of patient trial, made to feel an interest in a "puzzle map," and each went on uninterruptedly to recovery and home. Another patient is the terror of the ward, in which she stays until ten o'clock in the morning, when she goes quietly to school and remains for two hours one of the most interested of them all. After leaving the school she again becomes ugly and irritable, and it is only the fear of being kept away from it that makes her at all controllable. Surely these scattered instances show results sufficient to justify the efforts made; but I am sure that, even where the results are not so marked, the school is at least an important adjunct to employment, games, out-of-door exercise, and amusements.

All alienists are now agreed that occupation, no matter what form it may assume, is one of the most important measures in the treatment of the insane; and, if the school does nothing more, it fills out a portion of the day, relieves to some extent the tedium of asylum life, and turns for a time at least the patient's morbid thoughts into healthier channels. Pascal says: "Whence comes it that this man who has lately buried his only son, and who this morning was so full of lamentation, at present seems to have forgotten all? Be not surprised," he replies; "he is altogether taken up with looking which way the stag will turn which his hounds have been pursuing so hotly for the past six hours. He needs no more. However full of sadness a man may be, he is happy for the time if you can only get him to enter into some diversion."

The same writer also says, "Without diversion no joy, with diversion no sorrow"; and if this be a truth applicable to the sane, who will doubt that it applies with equal force to those of unsound mind?

The treatment pursued in cases of bodily disease has been not inaptly used to illustrate this system. To deprive the stomach altogether of food in case of trouble in that organ would be fatal; instead, by administering suitable foods, varied, simple, and in limited quantities, we may overcome the disease and bring about a healthy condition; so, too, in disease of the brain, if intellectual food be given in suitable quantity and form, why should we not expect equally good results?

While I would not exaggerate the importance of this system, my experience leads me to believe that much is to be expected from its conscientious and persistent use, and I would fain hope that the time is not far distant when, in every well-organized hospital for the insane, a school will be considered one of the essential features in "ministering to the mind diseased."

Some novel instances of intelligence and human-like traits in animals have recently come under our notice. A terrier dog at Yverdon, Switzerland, pays regular visits at Lausanne, going over and returning by train, and always getting out at the right stations. A cat at Montreux, which can open doors, heard another cat outside mewing to get in. No one answering the request, it rose from the chair on which it was sleeping, walked across the room to the door, opened it, and let its friend in. A tow-horse on a Boston street car, when his turn to work is about to come, quietly drops back behind his fellows, so as to be last in the line and evade the work he was to do. A horse, stabled with his mate and a third horse, stole hay from the stranger to give to his mate, while he was contented with the ration that had been allotted him; and a horse in a team, nibbling some rich grass on his side, gave at intervals mouthfuls of it to his companion, which could not reach it.

THE LIMITS OF STATE-DUTIES.*

By HERBERT SPENCER.

OF the many reasons for restricting the range of governmental actions, the strongest remains to be named. The end which the statesman should keep in view as higher than all other ends, is the formation of character. And if there is entertained a right conception of the character which should be formed, and of the means by which it may be formed, the exclusion of multiplied State-agencies is necessarily implied.

"How so?" will doubtless be the exclamation of many. "Is not the formation of character the end to which much of the legislation we advocate is directed? Do we not contend that an all-important part of the State's business is the making of good citizens? and are not our school-systems, our free libraries, our sanitary arrangements, our gymnasia, etc., devised with the view of improving their natures?"

To this interrogative reply, uttered with an air of astonishment and an implied conviction that nothing remains to be said, the answer is that everything depends on the goodness of the ideal entertained and the appropriateness of the appliances for realizing it; and that both of them are radically wrong.

These paragraphs sufficiently indicate the antagonist views to be here discussed. Let us now enter on the discussion of them systematically

Upward from hordes of savages to civilized nations, countless examples show that to make an efficient warrior preparation is needed. Practice in the use of weapons begins in boyhood; and throughout youth the ambition is to be a good marksman with the bow and arrow, to throw the javelin or the boomerang with force and precision, and to become an adept in defense as well as in attack. At the same time speed and agility are effectually cultivated, and there are trials of strength. More relevant still to the end in view comes the discipline in endurance; sometimes going to the extent of submission to torture. In brief, each male of the tribe is so educated as to fit him for the purposes of the tribe—to fit him for helping it in maintaining its existence, or subjugating its neighbors, or both. Though not a State-education in the modern sense, the education is one prescribed by custom and enforced by public opinion. That it is the business of the society to mold the individual is asserted tacitly if not openly.

With that social progress which forms larger communities

* From Justice, being Part IV of the Principles of Ethics, now in press of D. Appleton & Co.

regularly governed, there goes a further development of State-education. Not only are there now deliberately cultivated the needful strength, skill, and endurance, but there is cultivated that subordination which is required for the performance of military evolutions, and that further subordination to leaders and to rulers without which the combined forces can not be used in the desired ways. It is needless to do more than name Greece, and especially Sparta, as exemplifying this phase.

With this practice went an appropriate theory. From the belief that the individual belonged neither to himself nor to his family but to his city, there naturally grew up the doctrine that it was the business of his city to mold him into fitness for its purposes. Alike in Plato and in Aristotle we have elaborate methods proposed for the due preparation of children and youths for citizenship, and an unhesitating assumption that in a good State, education must be a public business.

Evidently, then, while war is the chief business of life, the training of individuals by governmental agency after a pattern adapted to successful fighting, is a normal accompaniment. In this case experience furnishes a tolerably correct ideal to be aimed at, and guidance in the choice of methods productive of the ideal. All free men have to be made as much as may be into military machines, automatically obedient to orders; and a unifying discipline is required to form them. Moreover, just as in the militant type the coercive system of rule which regimentation involves, spreads from the fighting part throughout the whole of the ancillary parts which support it; so, there naturally establishes itself the theory that not soldiers only, but all other members of the community, should be molded by the government into fitness for their functions.

Not recognizing the fundamental distinction between a society which, having fighting for its chief business, makes sustentation subordinate, and a society which, having sustentation for its chief business, makes fighting subordinate, there are many who assume that a disciplinary policy appropriate to the first is appropriate to the last also. But the relations of the individual to the State are in the two cases entirely different. Unlike the Greek, who, not owning himself was owned by his city, the Englishman is not in any appreciable degree owned by his nation, but in a very positive way owns himself. Though, if of fit age, he may on great emergency be taken possession of and made to help in defending his country; yet this contingency qualifies to but small extent the private possession of his body and the self-directing of his actions.

Throughout a series of chapters we saw that the progressive establishment by law of those rights which are deduced by ethics, made good the free use of himself by each individual, not only

against other individuals but, in many respects, against the State: the State, while defending him against the aggressions of others, has in various directions ceased to aggress upon him itself. And it is an obvious corollary that in a state of permanent peace this change of relation would be complete.

How does this conclusion bear on the question at issue? The implication is that whereas the individual had to be molded by the society to suit its purposes, the society has now to be molded by the individual to suit his purposes. Instead of a solidified body-politic, wielding masses of its units in combined action, the society, losing its coercive organization, and holding together its units with no other bonds than are needed for peaceful co-operation, becomes simply a medium for their activities. Once more let me emphasize the truth that since a society in its corporate capacity is not sentient, and since the sentiency dwells exclusively in its units, the sole reason for subordinating the sentient lives of its units to the unsentient life of the society, is that while militancy continues the sentient lives of its units are thus best preserved; and this reason lapses partially as militancy declines, and wholly as industrialism becomes complete. The claim of the society to discipline its citizens disappears. There remains no power which may properly prescribe the form which individual life shall assume.

"But surely the society in its corporate capacity, guided by the combined intelligences of its best members, may with advantage frame a conception of an individual nature best fitted for harmonious industrial life, and of the discipline calculated to produce such a nature?" In this plea there is tacitly assumed the right of the community through its agents to impose its scheme—an assumed right quite inconsistent with the conclusions drawn in foregoing chapters. But not here dwelling on this, let us ask what fitness the community has for deciding on the character to be desired, and for devising means likely to create it.

Whether the chosen ideal of a citizen, and the chosen process for producing him, be good or bad, the choice inevitably has three implications, any one of which condemns it.

The system must work toward uniformity. If the measures taken have any effect at all, the effect must in part be that of causing some likeness among the individuals: to deny this is to deny that the process of molding is operative. But in so far as uniformity results advance is retarded. Every one who has studied the order of nature knows that without variety there can be no progress—knows that, in the absence of variety, life would never have evolved at all. The inevitable implication is that further progress must be hindered if the genesis of variety is checked.

Another concomitant must be the production of a passive re-

ceptivity of whatever form the State decides to impress. Whether submissiveness be or be not part of the nature which the incorporated society proposes to give its units, it can not enforce its plans without either finding or creating submissiveness. Whether avowedly or not, part of the desired character must be readiness in each citizen to submit, or make his children submit, to a discipline which some or many citizens determine to impose. There may be men who think it a trait of high humanity thus to deliver over the formation of its nature to the will of an aggregate mostly formed of inferior units. But with such we will not argue.

One further necessary implication is that either there exists no natural process by which citizens are in course of being molded, or else that this natural process should be superseded by an artificial one. To assert that there is no natural process is to assert that, unlike all other beings, which tend ever to become adapted to their environments, the human being does not tend to become adapted to his environment — does not tend to undergo such changes as fit him for carrying on the life which circumstances require him to lead. Any one who says this must say that the varieties of mankind have arisen without cause; or else have been caused by governmental action. Any one who does not say this must admit that men are in course of being naturally adjusted to the requirements of a developed social state; and if he admits this, he will hesitate before he asserts that they may be better adjusted artificially.

Let us pass now from these most abstract aspects of the matter to more concrete aspects.

It is decided to create citizens having forms fit for the life of their society. Whence must the conception of a fit form be derived? Men inherit not only the physical and mental constitutions of their ancestors, but also, in the main, their ideas and beliefs. The current conception of a desirable citizen must therefore be a product of the past, slightly modified by the present; and the proposal is that past and present shall impose their conception on the future. Any one who takes an impersonal view of the matter can scarcely fail to see in this a repetition, in another sphere, of follies committed in every age by every people in respect of religious beliefs. In all places and in all times, the average man holds that the creed in which he has been brought is the only true creed. Though it must be manifest to him that necessarily in all cases but one, such beliefs, held with confidence equal to that which he feels, are false; yet, like each of the others, he is certain that his belief is the exception. A confidence no less absurd, is shown by those who would impose on the future their ideal citizen. That conceived type which the needs of past and present times have generated, they do not doubt would be a type

appropriate for times to come. Yet it needs but to go back to the remote past, when industrial life was held contemptible and virtue meant fortitude, valor, bravery; or to the less remote past when noble meant high-born while laborer and villein were equivalents; or to the time when abject submission of each grade to the grade above was thought the primary duty; or to the time when the good citizen of every rank was held bound to accept humbly the appointed creed; to see that the characters supposed to be proper for men were unlike the characters we now suppose proper for them. Nevertheless, the not-very-wise representatives of electors who are mostly ignorant, are prepared, with papal assumption, to settle the form of a desirable human nature, and to shape the coming generation into that form.

While they are thus confident about the thing to be done, they are no less confident about the way to do it; though in the last case as in the first, the past proves to them how utter has been the failure of the methods century after century pursued. Throughout a Christendon full of churches and priests, full of pious books, full of observances directed to fostering the religion of love, encouraging mercy and insisting on forgiveness, we have an aggressiveness and a revengefulness such as savages have everywhere shown. And from people who daily read their bibles, attend early services, and appoint weeks of prayer, there are sent out messengers of peace to inferior races, who are forthwith ousted from their lands by filibustering expeditions authorized in Downing Street; while those who resist are treated as "rebels," the deaths they inflict in retaliation are called "murders," and the process of subduing them is named "pacification."

At the same time that we thus find good reason to reject the artificial method of molding citizens as wrong in respect alike of end and means, we have good reason to put faith in the natural method—the spontaneous adaptation of citizens to social life.

The organic world at large is made up of illustrations, infinite in number and variety, of the truth that by direct or indirect processes the faculties of each kind of creature become adjusted to the needs of its life; and further, that the exercise of each adjusted faculty becomes a source of gratification. In the normal order not only does there arise an agent for each duty, but consciousness is made up of the more or less pleasurable feelings which accompany the exercise of these agents. Further, the implication is that where the harmony has been deranged, it gradually re-establishes itself—that where change of circumstances has put the powers and requirements out of agreement, they slowly, either by survival of the fittest or by the inherited effects of use and disuse, or by both, come into agreement again.

This law, holding of human beings among others, implies that

the nature which we inherit from an uncivilized past, and which is still very imperfectly fitted to the partially civilized present, will, if allowed to do so, slowly adjust itself to the requirements of a fully civilized future. And a further implication is that the various faculties, tastes, abilities, gradually established, will have for their concomitants the satisfactions felt in discharging the various duties social life entails. Already there has been gained a considerable amount of the needful capacity for work, which savages have not; already the power of orderly co-operation under voluntary agreement has been developed; already such amounts of self-restraints have been acquired that most men carry on their lives without much impeding one another; already the altruistic interests felt by citizens in social affairs at large, are such as prompt efforts, individual and spontaneously combined, to achieve public ends; and already men's sympathies have become active enough to generate multitudinous philanthropic agencies —too multitudinous in fact. And if, in the course of these few thousand years, the discipline of social life has done so much, it is folly to suppose that it can not do more—folly to suppose that it will not in course of time do all that has to be done.

A further truth remains. It is impossible for artificial molding to do that which natural molding does. For the very essence of the process as spontaneously carried on, is that each faculty acquires fitness for its function by performing its function; and if its function is performed for it by a substituted agency, none of the required adjustment of nature takes place; but the nature becomes deformed to fit the artificial arrangements instead of the natural arrangements. More than this: it has to be depleted and dwarfed, for the support of the substituted agencies. Not only does there result the incapable nature, the distorted nature, and the nature which misses the gratifications of desired achievement; but that the superintending instrumentalities may be sustained, the sustentation of those who are superintended is diminished: their lives are undermined and their adaptation in another way impeded.

Again, then, let me emphasize the fundamental distinction. While war is the business of life, the entailed compulsory co-operation implies molding of the units by the aggregate to serve its purposes; but when there comes to predominate the voluntary co-operation characterizing industrialism, the molding has to be spontaneously achieved by self-adjustment to the life of voluntary co-operation. The adjustment can not possibly be otherwise produced.

And now we come round again at last to the general principle enunciated at first. All reasons for going counter to the primary law of social life prove invalid; and there is no safety but in conformity to that law.

If the political meddler could be induced to contemplate the essential meaning of his plan, he would be paralyzed by the sense of his own temerity. He proposes to suspend, in some way or degree, that process by which all life has been evolved—to divorce conduct from consequence. While the law of life at large is to be partially broken by him, he would more especially break that form of it which results from the associated state. Traversing by his interference that principle of justice common to all living things, he would traverse more especially the principle of human justice, which requires that each shall enjoy the benefits achieved within the needful limits of action: he would redistribute the benefits. Those results of accumulated experiences in each civilized society which, registered in laws, have, age after age, established men's rights with increasing clearness, he proposes here or there to ignore, and to trespass on the rights. And, whereas in the course of centuries, the ruling powers of societies, while maintaining men's rights against one another more effectually, have also themselves receded from aggressions on those rights, the legislative schemer would invert this course, and decrease that freedom of action which has been increasing. Thus his policy, setting at naught the first principle of life at large and the first principle of social life in particular, ignores also the generalized results of observations and experiments gathered during thousands of years. And all with what warrant? All for certain reasons of apparent policy, every one of which we have found to be untrustworthy.

But why needs there any detailed refutation? What can be a more extreme absurdity than that of proposing to improve social life by breaking the fundamental law of social life?

VIEWS OF RUNNING WATER.

By M. J. PICCARD.

IF we ask a person who has not thought about the matter to represent with a pencil, from memory, a stream or fall of water, in nine cases out of ten he will return the paper after having timidly ventured upon a few parallel scratches, looking as much as anything else like the ruts in a road or the hairs of a horse's tail. Yet we see liquids every day flowing along the gutter, and from bottles or pitchers; and we have all played near brooks and cascades. The persons who trace the parallel lines we have spoken of suppose they are representing the path traveled by the particles of water—that is, a movement, an immaterial thing which by its very nature defies all graphic representation. It is true that a luminous point in very rapid motion leaves on the retina the impression of a line. We are thus authorized to

represent a flash of lightning, the course of a shell, and a gunshot; but we hesitate to resort to that artifice to represent the flight of an arrow through the air or the movement of a sword to strike. It will be well to make only a moderate use of it in representing water. In fact, these parallel lines do not exist, at least not under that form. Furthermore, lines do not show whether the stream is going to the right or to the left, or *vice versa*.

The effects accompanying the motion of water are, notwithstanding their extreme variety and apparent complication, subject to unchangeable hydraulic laws which it is possible to fix, with the aid of reason and experiment. Observation, even by itself, in the long run, develops an unconscious apperception in the inhabitant of the banks, whether he be fisherman, boatman, or raftsman. Special acquirements enable him to divine, according to the appearance of the surface, a thousand invisible things that are going on under the water. We do not, of course, intend to explore so vast a domain to the bottom, but to indicate how the subject may be approached, and how art and science are benefited by the investigation of it. What are the typical phenomena of running water, which, to simple sight, give rise to the impression of motion in a definite direction, and which are susceptible of being rendered graphically? Let us begin our experiments by fixing a low dam across an even-bottomed channel. Immediately above the dam the interrupted water will form a swell, on the back of which a system of fine parallel striæ may be observed. According to the depth and speed of the current, a second or several similar swells may be formed, but of lessening dimensions (Fig. 1). These are stationary swells, which we call eddy-waves or ripples.

To simplify the matter, we neglect what goes on below the dam. On the other hand, we inquire what happens when the dam is

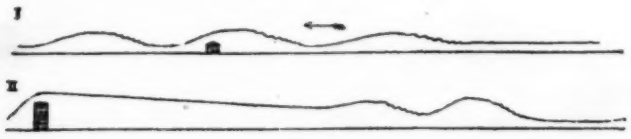

FIG. 1.

high enough to force the formation of a small lake. We should be apt to suppose that the water would pass, gradually diminishing in speed and increasing in depth, following a regular curve, from the condition of motion to that of relative repose. This is not the case. The passage is made suddenly, with a shock. The whole system of ripples and striæ which was before immediately at the head of the dam is transferred to the place where the water of the stream strikes against the comparatively still water of the

lake. Besides, the two points being possibly distant from one another, the effect, or the eddy, appears before the cause, the obstacle (Fig. 1, ii). It is in this way, by the appearance of the surface, that the raftsman going down a river can judge, from the variations of speed, of the depth of the stream, and the size and position of reefs hidden under the water, frequently a considerable distance below the point where he is. Is not this the supreme end of art—to cause to be foretold by outer forms what is going on in the domain of invisible things, and to divine the reality without laying it bare? Water lends itself eminently to this end. It obeys mechanical laws, not as a machine which exposes them bluntly and fatally, but with a variety of suggestions and a lightness that leave the field clear for the imagination.

Let us, in our experimental canal, reduce the dam to a single obstacle in the middle of the stream. The eddy-wave, instead of being straight, bends around on either side, and takes the form of a parabola with a $\wedge$ more or less open according to the velocity of the stream. Moreover, the branches of the parabola, turned back by the side-walls of the canal, if it is not too broad, take a figure below the obstacle in which the first traces of a lozenge appear (Fig. 2, iii). Lastly, let us place the obstacles on the sides

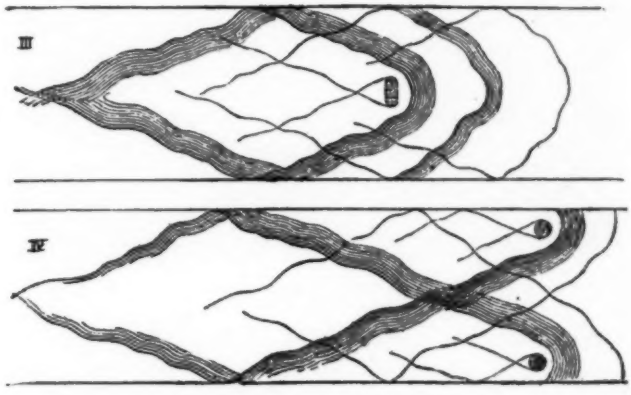

FIG. 2.—FORMS OF EDDY-WAVES.

of the canal. We find that the waves are turned toward the middle of the stream, and that by intercrossing with those coming from the opposite bank, and by their own return, a system of lozenges is produced on the surface of the water (Fig. 2, iv, and Figs. 3 and 4).

In this we see the pre-eminently typical phenomenon of running water. Every inequality of the shore, whether promontory or bay, plant or pebble, stake or bridge pier, is the starting-point for centripetal lines which go on in graceful undulations to lose themselves in the stream, or, meeting with others, to form qua-

drilles of rhombs, often with the most charming effect. By the direction of these lines the observer divines the course of the current, and their inclination furnishes him with an exact measure of its velocity.

In the case of cascades, the greater variety of the phenomena forces us to go more into detail. We begin with an inclined vessel, glass, pot, or pail, in process of emptying. How does the sur-

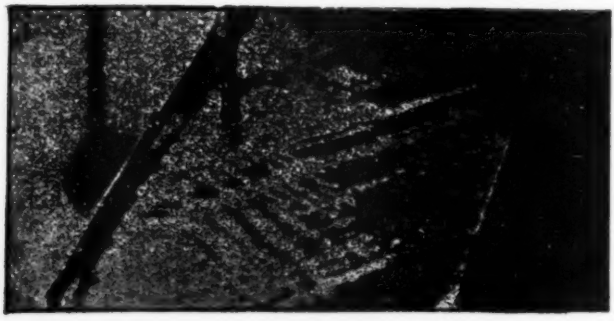

FIG. 3.—SYSTEM OF LOZENGES PRODUCED BY EDDY-WAVES.

FIG. 4.—SYSTEM OF LOZENGES PRODUCED BY EDDY-WAVES.

face of the outrunning liquid look? It would be safe to wager ten to one that any person at the first instance would represent it as in Fig. 5, v, by parallel parabolic lines. We not rarely find artistic productions in this style dating from the time when they composed landscapes from fancy in their studios. Without being too severe on these errors, which are still not far away from us, we will try to do better, and to correct the faults of the figure, one at a time.

We lay aside, for the moment, the usual ribbon-like form, which is false, and examine first the question of the vertical lines. They are formed by the series, *A*, *a*, *a*, of points by which the same molecule of water passes (or is supposed to pass) successively. Is there any proof of their material existence? No. It must be admitted that in certain cases, like that of a thin sheet falling from

a regular dam or gliding over a smooth rock, the irregularities of the latter may produce lines in the direction of the current; but true painters make only the most moderate use of the straight line.

Are there not more grounds of resemblance between the points *A* and *B* or *α* and *β* which appertain, however, to different generators than between the points *A* and *α* of the same generator? Suppose the liquid sheet decomposed into its elementary veins; each of them is differently constituted in its several parts. At its

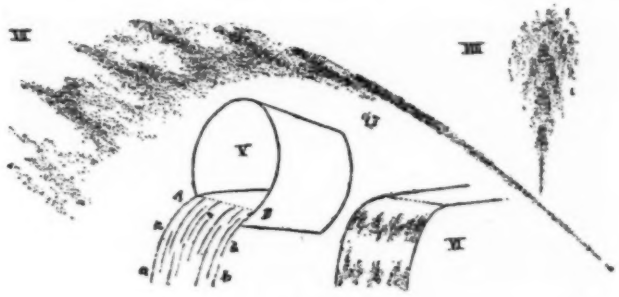

FIG. 5.

origin it is full, uniform, and transparent; lower down it shows real or apparent swellings and contractions; and still farther down it resolves itself into distinct drops. The water-sheet should consequently have an entirely different constitution at *A* from that at *α*, but the same at *A* and at *B*. It is proper, therefore, to represent as similar, not the points of the same parabola, but those of the same horizontal range; so, in the reflection of surrounding objects, the surface at the upper part of the parabola, making a smaller angle with the horizon, would produce a different effect from that at the lower part. At *A* and *B* it would reflect chiefly the sky; at *a* and *b*, perhaps, the rocks; while at *α* and *β* it would be white and reflect nothing.

Independently of phenomena which we are still to study, and paradoxical as it may appear, we can say that, if there are bands or zones in a cascade, they are rather horizontal than vertical. Our design vi, Fig. 5, still false and incomplete in many respects, looks more like a real fall of water than the design v, Fig. 5, with which we started. By this horizontal rather than vertical disposition of the effects of light, color, and reflections, the image gains much in life and truth.

When the eye has become accustomed, by repeated observations, to the peculiarities of the liquid elements, it can at last distinguish, in each jet of any velocity, a jerking or vibratory movement, a kind of trepidation or pulsation, directed horizontally, up and down, or down and up. It was believed formerly to be an optical illusion; but instantaneous photography and other obser-

vations establish beyond a doubt that the motion of a jet of water is never continuous, but is intermittent, periodic. Design vii, Fig. 5, which represents a jet from a hydrant or fire-engine at the moment of elevating, and design viii, representing a vertical jet from a narrow hole, are schematic but faithful reproductions of numerous observations. The photographs of Figs. 6 and 7, taken from nature at the overflow of a factory flume on Sunday, when no wheel or turbine was moving, are convincing.

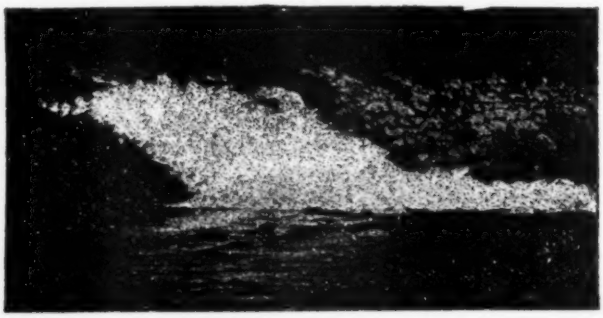

FIG. 6.—VIBRATORY MOTION OF FALLING WATER.

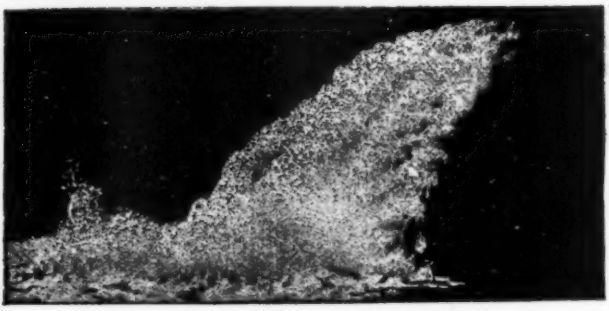

FIG. 7.—VIBRATORY MOTION OF FALLING WATER.

This intermittent character of the stream is due to the same cause as the sound produced by the air in blowing through a keyhole; it is produced in the same way as the wavy tufts in smoke escaping from a chimney. Water, as well as air, is elastic, but in a less degree, and differences in its pressure are propagated in waves. Ample explanations on the subject may be found in the chapters on undulations in treatises on physics; but the theory of the liquid wave is complicated, and far from being exhausted. We limit ourselves to saying that water, like air, is greatly disposed, every time the velocity of the stream is changed, by shock against a foreign body or by an abrupt contraction or enlargement of the channel, to go into vibrations and to communicate them to the walls of the orifice whence it escapes or to any object against which

it strikes. Persons of delicate ear believe that they can distinguish the fundamental note of a cascade. Savart has determined the tone of a liquid vein. Another cause of discontinuity in a cascade is derived from waves in the river or the supply-basin, which, continuing into the fall, produce puffs and ripples. The phenomenon is accentuated by the resistance of the air. When, by any means, one of these jets deviates a little from the route which the one before it followed, the masses projected ahead, having to open the way, are retarded, and are then joined by those which follow them. The phenomenon is one of accumulation, like that which produces the billows on the sea-coast and the bars at the mouths of rivers, under the action of the tide. But shortly these bold spurts, rended and scattered by the same cause that produced them, the friction of the air, meet their end by being reduced to dust. When too near, the observer, engaged with a thousand details, is not struck so much as he is at a distance, by the phenomena as a whole and their periodicity. We can distinguish, then, the periodical ranges of jets which are partly transformed into spurts, and in the tumultuous rush between two rocks the bubbles or vibrations produced by the shock. The line is nowhere vertical.

When the waves coming down from the feeding-basin reach the upper edge of the cascade parallel to that edge, the bubbles are dispersed in horizontal bands. But if the wave comes down at an angle, it forms rows of inclined fringes; while, if the cascade is fed by a brook with the characteristic waves of Fig. 2 (iv), starting from both shores toward the middle, those waves will continue the same in the cascade in the shape of more or less stationary lozenges. In this case, again, we are far away from vertical parallel lines.

It is time to look more closely at the form and constitution of the liquid sheet. In Fig. 5 (v) it is represented by two parallel lines as a ribbon, such as any person not instructed would design from memory. It is in reality wholly different, as will appear from Fig. 8 (x). Let us begin at the top. Immediately at the opening of the flow, from the moment when it is wholly abandoned to itself, the sheet begins to narrow and take the form of a triangular tongue, pointed below. Let us, before we go further, look into the cause of this first change of form. When we make the experiment with an inclined cylindrical vessel, as in Fig. 5 (v), our inclination is at first to attribute the contraction to the oblique centripetal direction communicated to the lateral molecules by the elliptical form of the surface of the water in the interior of the vessel. This explanation is insufficient, for the sheet escaping from a tube, a canal, or a prismatic vase with parallel sides, assumes the same form Figs. 8 (x), 13, 14, 15, 16, and 17. The ex-

planation that next suggests itself depends on the acceleration of velocity during the fall, which should have as a necessary result a progressive diminution of the section-surface. It may be proved experimentally that this has nothing to do with the triangular form by giving an upward direction to the jet from a flattened tube; the stream takes the form of a tongue all the same (Fig. 10).

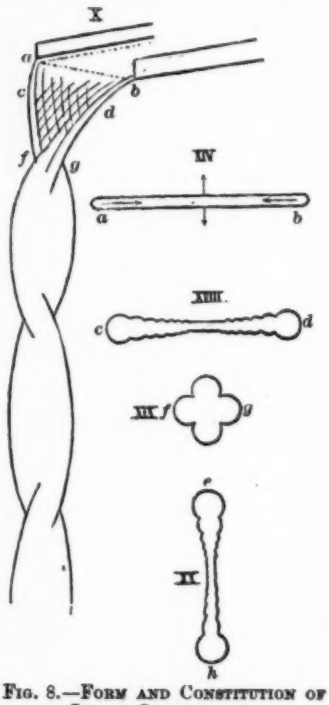

FIG. 8.—FORM AND CONSTITUTION OF A LIQUID SHEET FALLING.

Is it because the lateral parts of the liquid ribbon, having to overcome in the canal or the tube a more considerable friction than in the central part of the current, have at their issue a less mean velocity than the latter, and are therefore attracted by them? The effect incontestably exists; but we shall demonstrate, when we come to speak of the liquid vein, that it is negligible in comparison with another cause. After trying these various causes and eliminating them one after the other, we are brought to the conclusion that the essential cause that draws toward the middle the edges of a liquid sheet falling freely is the force of cohesion, or capillary tension. It is the same force that causes a freely suspended liquid mass to take the spherical form, as in Plateau's well-known experiment, and in the world of the stars. It is only in this state of least surface that the attractions between the mole-

FIG. 9.

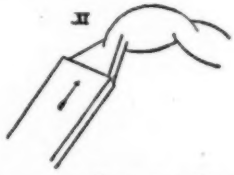

FIG. 10.—TONGUE-LIKE FORM OF A JET OF WATER SPURTING FROM A FLATTENED TUBE.

cules are in equilibrium. A falling liquid sheet will, therefore, tend toward a cylindrical or contracting form. Does it really become a cylinder and keep the form? What takes place lower down? These questions require knowledge of other peculiarities of the primary tongue.

When water is subjected to a shock or to pressure, the pressure does not distribute itself insensibly through all the mass with

gradual diminution. We have already shown this in the formation of swells by changes of slope in streams. We have another experiment. Slowly close a faucet till the liquid vein flows in a mere thread (Fig. 11, xv). The orifice in this case being perfectly cylindrical, the contraction is due on one side to the adherence of the liquid to the sides of the hole, and on the other side to acceleration, and takes place equally in all directions. Intercalate a solid body or a liquid surface at a few centimetres from the hole. The pressure at the base of the column augmenting by resistance, we might expect the vein to take the continuous form of two reversed cones (Fig. 11, xvi). It does not, but takes the form of swellings, of knots regularly placed, which give the vein the appearance of a chaplet (Fig. 11, xvii). This phenomenon, interesting as a case of action at a distance, and also as a case of vibrating action, has been observed by Savart and is described by him in the second of his memoirs. What the pressure caused by shock produces here, the pressure caused by cohesive attraction (capillary pressure or superficial tension) produces on the edges of the liquid sheet: a series of knots is formed. The section of the jet loses the form of the hole as soon as it leaves it, but the increase of thickness at the expense of breadth does not take place continuously; the central sheet is still thin and even, while the edges are already transformed into thick cords followed by other smaller ones. It is the same system of swells and ripples that we met before. The striæ of one side cross those of the other side, and the tongue is covered with a system of lozenges producing a very pretty effect (Fig. 8, x, and, in section, xviii).

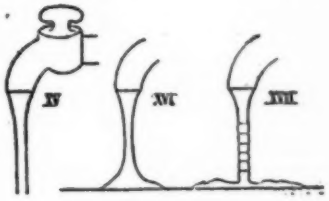

FIG. 11.

Now that we know the details of the form and constitution of the upper part of the liquid sheet, let us see what occurs lower down. On issuing from the canal, the lateral molecules of the sheet are subjected to the action of a component of horizontal centripetal velocity which turns them toward the middle. The particles in the middle, on the other hand, thrown toward the outside, acquire also a horizontal component, but centrifugal (Fig. 8, xiv). The point of stable equilibrium is where the jet has a cylindrical form. But there are various things to be observed.

As the rope-walker does not cease oscillating when he reaches the point of stable equilibrium, but by virtue of his inertia goes as far beyond it on the other side, so the horizontal oscillation of the molecules of water, repeating itself, produces a new sheet in a plane perpendicular to the first one, but this time in the form of a double tongue—that is, of a disk or lentil. The phenomenon repeating

itself anew, a second contraction is followed by a new disk in the same plane as the first tongue, and so on; the disks alternating in the two vertical planes of breadth and depth, as in a paper *fidibus*. In the photographs reproduced in Figs. 16 and 17, a mirror fixed at an angle of 45° in the vertical plane gives, besides the front view of the vein, its image as seen in profile. A mechanical demonstration can be given of the movement of which the vein is the seat by a parallelogram of basket-work, which we press upon while holding it horizontally, and making it pass, by alternate compression of the extremities, from the oblong to the square shape, and then to the oblong the other way, return to the square, etc. The example of the *fidibus* is not quite exact. We comprehend at first that, in consequence of the acceleration, the disks will continue lengthening and deviating more and more—we can easily distinguish eight of them, sometimes twelve or more—till at last the molecules of water yielding to this dissociating action of weight group themselves in little cohesion-drops. There is another difference, in that the disks are not superposed as in the *fidibus*, but are boxed into one another—that is, one begins to form by deviation before the preceding one has done contracting. This is the necessary consequence of a third difference: that the disks are not plainly flat, but are thin in the middle, like the primitive tongue from which they are derived, and are flanked by thick cords on the edges (Fig. 8, xviii). We can, therefore, regard each disk as formed by the shock of the two cords of the disk above it. If this shock is exerted in a horizontal plane, the new disk will spread out equally in every direction, having its center at the point of the shock. Acceleration becoming a factor, the spreading is prolonged farther down than up; the disk is thrown out of center, but does not for that cease to encroach upon its predecessors. The case is like that of the links of a chain, which enter within one another. Nowhere, then, not even at the point of minimum surface, can the jet be cylindrical; at the minimum, it assumes the form of a rounded cross (Fig. 8, xix).

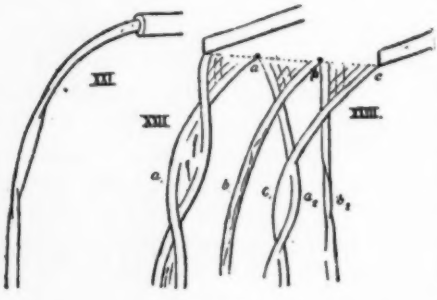

FIG. 12.

Thus we find that, in the phenomenon so simple in appearance of a fall of water, all the complications that arise one after another under the fullest examination are explained logically down to the most minute details. We can already draw one important conclusion: every mass of falling water, if it is not rigorously cylin-

drical and vertical in its origin, becomes necessarily the seat of horizontal oscillations—independently of the vertical vibrations which were first considered. Not a single molecule of which the

Fig. 13.

Fig. 14.

Fig. 15.

Instantaneous Photographs showing the Form of Liquid Sheets escaping from a Canal or from a Prismatic Vessel with Parallel Walls.

mass is composed follows a straight or parabolical line in its fall. All, without exception, describe a sinuous or zigzag course. Such is the general phenomenon. Let us follow out some of its details.

For the jet to be rigorously cylindrical in its origin is not a sufficient condition of its preserving that form. When it issues horizontally in full gush from a fountain, the parabolic trajectories, upper and lower, lose their parallelism and cause by approaching one another a flattening of the jet. From this fact arise horizontal undulations, only slightly marked, it is true, but which suffice, if the light is favorable, for producing the illusion of swellings and contractions (Fig. 12, xxi). Even when a liquid vein issues vertically from the bottom of a vessel by a circular hole, it assumes a helicoidal form in consequence of a motion of rotation which develops gradually within the vessel. This is independent

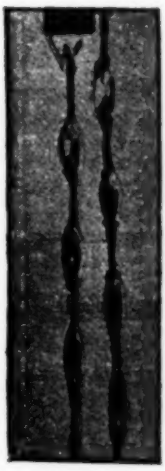

Fig. 16.

Fig. 17.

Escaping Liquid Veins and their Profiles, as shown by Reflection at 45° in the Vertical Plane.

of the vertical vibrations, of which the bottom of the vessel becomes the seat, and which it communicates to the whole jet.

The tongue-shaped sheet is bordered on its outer edge, as we have already shown, by swellings or cords, when everything is rigorously symmetrical; these two cords, meeting at the base of

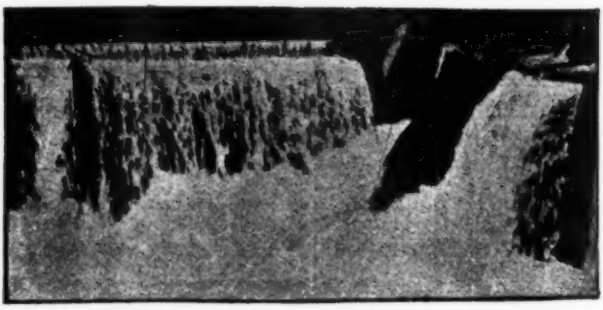

FIG. 18.—INSTANTANEOUS PHOTOGRAPH SHOWING THE CORDS FORMED ON THE EDGES OF LIQUID TONGUES, AS IS SEEN IN FIG. 14.

the tongue and flattening against one another, form a second sheet in a plane perpendicular to the former one—and so on. But when, for any reason, on account of the slight inclination of the canal, for example, it happens that the two cords do not exactly meet, one passes before the other, and one of two things may result. They will either roll up upon one another like a corkscrew and

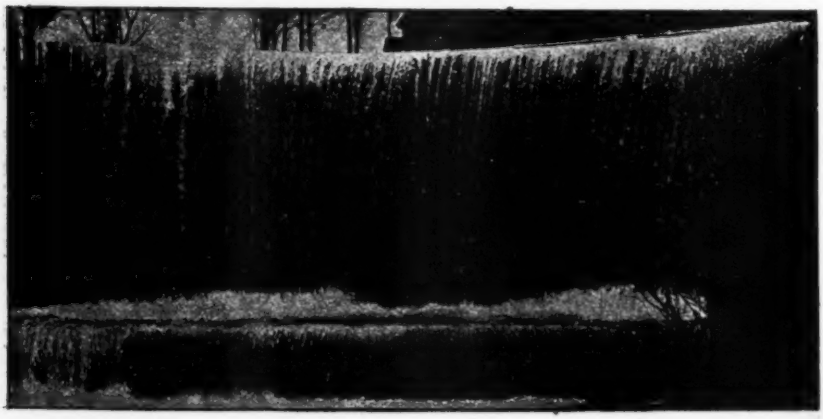

FIG. 19.—PHOTOGRAPH SHOWING THE TREMULOUSNESS PECULIAR TO CASCADES WITH BROAD SHEETS.

follow a helicoidal course (Fig. 12, xxii, and 13), or else, by some trifling cause they will miss, and, lanced in opposite directions, without regarding the thin median sheet that connects them, they will go each to its own side, never to find one another. The pri-

mary sheet is cut into two veins, which, losing trace of their common origin, remain definitely separated (Fig. 14).

When the sheet is very shallow and very wide, like that which spreads over a river dam, insignificant inequalities at the dam are enough to provoke a division into many distinct sheets. Consider two of these near one another (Fig. 12, xxiii). It may happen that cord a of the left arc and cord c of the right arc, coming very near to each other, join; thus are united molecules of water which an instant before had come out of the sluiceway at a considerable distance apart. Inversely, two molecules, neighbors till then arrived together at the same point b of the dam, are separated, one passing by b_1, the other by b_2, to reach the bottom widely separated. So also with the molecules a_1 and a_2. In the most regular fall, not a single molecule reaches the bottom by the most direct way. The same molecules which were traveling parallel in the bed of the canal, quietly keeping alongside of one another, seem, as soon as they reach the dam, to be suddenly taken with a frantic thirst for liberty, throwing themselves to the right and the left, joining, separating, and joining again; it is a go and come that never ceases till they find themselves newly imprisoned in the bed of a brook. Hence the serpentine course of the threads of water, the sparkling, the tremulousness which are common to cascades with broad sheets, and constitute their charm. The photographic reproductions (Figs. 18 and 19) represent, as well as can be done graphically, most of the characteristics which we have just described.

This is what occurs normally, under the influence of weight, cohesion, and inertia. When water runs out from a regular orifice, or over a horizontal dam, how complicated everything becomes when these conditions of regularity are not fulfilled, or when other forces come into play! One force that plays an important part in this matter is adherence between the molecules of the water and the walls of the vessel. This it is which often causes a liquid to follow a different way from that which is mechanically pointed out to it by inertia, weight, and cohesion. It then springs out into prohibited roads; instead of going to the cup held out to receive it, it chooses to follow the rim of a bottle and to spatter itself over the white cloth. Instead of precipitating itself into the pool with its companions, some capricious vein allows itself to be tempted by a nothing, to glide along a wall of rocks, and to trace those silvery threads which are often more graceful than the cascade itself. Yet adherence is a physical force, the effects of which may be foreseen and calculated up to a certain point. There are other factors, varying infinitely, but also calculable, which constitute, we might say, a part of the cascade, and contribute to impress a special, individual character on

it—its height, the larger or smaller mass of water, the nature of the bed and the form of the opening through which the water escapes, the shape of the rocks over which it flows or against which it rebounds. Each stream of water has its own life. Pagans have personified rivers by surrounding their sources and their shores with divinities. To us, also, the torrent and its cascades are the soul of the valley.

And yet there is another and a foreign force that plays havoc with all our calculations—the wind. "Then, in the air, there are endless assaults between the coquettish sylph and the rogue who pursues her. Sometimes he seizes her of a sudden and carries her off with a puff to drop her as abruptly; sometimes he entices her and plays a thousand tricks upon her; then he grows bolder, embraces her, and makes her dance upon herself with a giddy velocity; and often he takes her so well on the wing that, like a flight of little floating clouds, she whitens in the distance in space. But soon the brook is formed again; it undulates and balances itself like a waving scarf, while all around a thousand limpid threads glide along the rock, and make a joyous court of falls in miniature to the green cascade."—*Translated for The Popular Science Monthly from the Revue Scientifique.*

CAN WE ALWAYS COUNT UPON THE SUN?

By GARRETT P. SERVISS.

THE study of the origin and development of species may be pursued with reference to the starry hosts, for there are different species of suns as well as of animals. The wide-ranging eye of the astronomer perceives in the dazzling orb whose rising turns night into day and whose beams vivify the face of the earth, only a minor representative of a great order of radiating bodies peopling the profundities of space. But, besides placing the sun in the comparatively humble rank to which he belongs by virtue of his inferiority in magnitude to many of his brilliant comrades, we are able to distinguish his particular breed, so to speak. He is not of the same kidney with such a sun as the dazzling Sirius, while the diamond radiance of Rigel and the sparkling blue beams of Vega proclaim that those stars are in some important respects different and more splendid organisms than our sun.

While there can be no question that suns have a life-history, a beginning and an end marking the termini of a regular process of development, and that consequently the stars that we see differ in age, still it is not yet possible to say with absolute certainty at just what point in the scale of solar development our sun, or any other

particular star, has arrived. According to some views, the sun is an older star than Sirius; according to others, it is younger. The question whether a sun is still approaching the climax of its radiative energy, or has passed that point and is descending the scale, is an important one as regards the ultimate destiny of inhabited worlds revolving around it. It is upon the revelations of the spectroscope, assisted by photography, that we must depend for the advance of our knowledge of the condition of the various orders of suns. Upon spectroscopic evidence the stars are ranged into four principal classes distinguished by the kind and extent of the absorption which their light undergoes in passing outward from their photospheres through their gaseous envelopes or atmospheres. Sirius stands as the most brilliant representative of the first class, sometimes called the white stars, in whose spectra the lines of hydrogen are very conspicuous while other lines are few and faint. Some of the stars of this class have a splendid blue tint in their light. More than half of all the stars whose spectra have been studied belong to the first class. Vogel thinks they are the youngest stars, and that their youthful fires represent the most intense development of solar heat. If they are the youngest, then, on account of their great number as compared with the other stellar classes, it is evident that the universe has not yet passed the high noon of life; in other words, that the starry system, taken as a whole, is still in its prime, if indeed it has as yet attained the summit of its development as a community of suns. But the correctness of Vogel's assumption that the stars of the first class are all younger than those of the other classes is seriously questioned, and, as Prof. Young says, "it is very far from certain that a red star is not just as likely to be younger than a white one as to be older."

The second class is represented by Capella and our own sun. These stars are evidently surrounded by a far more complicated envelope than is the case with the white stars. Metallic vapors suspended above their photospheres in great variety serve to absorb a large part of their radiation, so that the spectrum of their light as it comes to us presents an enormous number of black lines, showing that it has been sifted through the vapors of iron, calcium, platinum, and many other metals, each of which, existing at a lower temperature than the fiercely glowing surface beneath, has arrested from among the passing rays those peculiar to itself. Some of the hydrogen lines also exist in the spectra of stars of the second class, but they are no longer conspicuous above the others. The second-class stars often called the solar and sometimes the yellow stars, are far less numerous than the white stars, the proportion, so far as known, being about one to six.

In the third class we come to the red stars, the majority of the stars of that color, as well as most of the variable stars, falling

within this category. In these stars the absorption of their vaporous envelopes is so pronounced that their spectra are darkened by bands as well as lines. Sometimes *bright* lines of hydrogen appear in the spectra of stars of this class, indicating that an envelope of that element surrounding them has blazed out with an intensity of heat exceeding that of the photosphere itself. Betelgeuse, the great orange-colored star in the shoulder of Orion, is a representative of the third class. The wonderful variable Mira, in Cetus, also belongs in the third class of stars.

The fourth class is small in number, and its members are inconspicuous in brightness and shine with a deep red light. Their spectra are also filled with bands of absorption which are peculiar in that they shade off gradually toward the blue end of the spectrum, while the bands in the third-class spectra shade off toward the red end. This peculiar spectrum appears to arise from a compound of carbon filling the atmosphere of the star. Variable stars also abound in the fourth class and bright lines are sometimes seen in their spectra. Even if we grant that the progress of stellar evolution is from the white through the yellow to the red stars, and so on to complete extinction, it does not appear possible to say with certainty that the stars of the fourth class are any closer to final extinguishment than those of the third. It would be a very beautiful thing if one variety of red stars could be recognized as representing a class younger than Sirius, while all other red stars were known to be older than the sun, but that can not be affirmed. So far as our present knowledge guides us, the most that we can assert is that red stars may be either the youngest or the oldest of suns, or some may be young and some old; but that, at any rate, they probably stand near one or the other end of the progression, since they are clearly inferior in efficiency of radiation to the other stellar varieties.

Now, as regards the existence of planets circling around the various classes of suns, we can only reason from analogy; and opinions upon the subject range all the way from Dr. Whewell's conclusion that the earth is probably the only inhabited world in the universe, to Dr. Chalmers's delightful picture of the starry heavens filled everywhere with intelligent beings worshiping their Creator. Suppose we examine the probable conditions prevailing around the stars of each of the four great classes. The white stars, like Sirius, possess an extraordinary potency of radiation. Their atmospheres are not strongly absorbent, and probably not extensive, and consequently nearly the full vigor of their beams is poured upon the satellites that surround them, if any such there be. According to recent estimates, Sirius, while shining with perhaps seventy times the light of our sun, is only between two and three times as massive, so that the intensity of its radiation is

enormously greater than the sun's. Planets situated as close to Sirius as the earth and the other inner planets of our system are to the sun, would be unable to endure, so far as their life-bearing functions are concerned, the gush of heat and blaze of light poured upon them—unless, indeed, the organization of living beings there were entirely different from that prevailing here. We should then expect such stars as Sirius, if they are the centers of planetary systems at all, to be surrounded by globes revolving at comparatively great distances and in long periods of time.

Coming to the second class, or solar stars, we find that the more extensive atmospheres which surround them, and absorb no inconsiderable portion of their rays, serve as a sort of protective curtain for their planets. There can hardly be a doubt that if the envelope of metallic vapors that incloses the photosphere of the sun were suddenly removed, life, at least in many of its more complex forms, would be banished from the earth, and perhaps be rendered impossible upon any planet nearer than Jupiter.

But it is the red stars and variable stars of the third and fourth classes that present the most unfavorable features from the planetary point of view. Probably no star belonging to these varieties is free from extensive and more or less spasmodic alterations in the amount and intensity of its radiation. Take such a star as Mira, for instance, alternately dying down almost to extinction and then blazing out with more than a thousand times its former brilliancy, these tremendous changes occupying, for a complete cycle, only eleven months! Is it possible to suppose that inhabited planets exist within the domain of an orb like that? When a sun is half smothered in absorbing vapors, and subjected to paroxysms such as those which are occasionally beheld when the atmosphere of a star appears to catch fire, as it were, and the lines of hydrogen and other elements flame bright like signals of conflagration, it can no longer be the center of a system of life-bearing worlds, no matter what its past history may have been in that respect.

It is apparent, from what we have just said, that progress by our sun in either direction—toward the white stars or toward the red stars—would, in the end, prove exceedingly uncomfortable if not fatal to the inhabitants of the earth. By the subsidence of the vapors of metals that now stripe the solar spectrum with their absorption we should be, in effect, removed into the presence of a Sirius whose fierce beams would smite the living world with death. On the other hand, let the sun sink into the condition of a red star, and become variable in its outpourings, and our condition would be even worse. If it be thought that a planet whose orbit is as eccentric as that of Mercury is hardly habitable because it receives twice as much solar heat at perihelion as at aphelion,

what is to be said of the condition of a planet subjected to the terrific mutations of Eta Argus, a star that in 1843 rivaled Sirius itself in brilliancy, and that since 1868 has been invisible to the naked eye, and has sunk as low as the eighth magnitude? Some of the comets undergo far less severe alternations than such a world must endure. In either direction, then, the prospect of solar evolution seems unfavorable, considered from the planetary standpoint. What the planet most wants is an unchanging and unchangeable sun. But this is impossible. In the presence of eternity a sun, whether it grows hot or grows cold, white or red, with age, is a thing as essentially evanescent as a zephyr.

But we can not rest with the assumption that, since the sun is evidently no Mira and no Sirius, therefore it is practically an unchanging radiator which for an indefinite period will continue to cause the earth to bloom in the beneficent effulgence of its life-inspiring rays. A sun may affect the welfare of its planets either through the gradual mutations which it undergoes in the course of its evolution, or through the more rapid and violent changes that characterize the stars that are ranked as variable. We have seen that most of these latter belong to the third and fourth classes, but there is reason to suspect that the majority of all the stars are variable to a slight degree, and evidence of variability in the case of the sun is furnished by the phenomena of sun-spots. A spectator, viewing the sun from a distant point in space, would perceive that its brilliancy was slightly increased once in about every eleven years. These accessions of light should correspond, not with the periods of fewest spots, but with those of most spots, because the energy of the sun's radiation is greatest during the spot maxima. At present a sun-spot maximum is approaching, and since last winter the face of the sun has frequently exhibited startling indications of the tremendous disturbances now affecting the solar globe. Our imaginary observer in space would probably behold at the present time a very slight increase in the sun's brilliancy, and this increase may go on for three or four years to come. While we, dwelling upon a globe that is bathed in the sun's rays, may be unable to perceive these variations directly, yet their effects have long been recognized by the changes that they produce in terrestrial magnetism. It is also highly probable that a perceptible influence upon the weather is exercised by variations in solar radiation corresponding with the presence or absence of sun-spots. So far as trustworthy observations have gone, it appears that the temperature upon the earth is slightly lower when sun-spots are most numerous. This is exactly the opposite to the effect that might have been anticipated; but as the observations from which the inference is derived are confined to India, it seems probable that the lowering of tempera-

ture, while primarily brought about by the condition of the sun, is directly due to the action of local causes, and that in other parts of the earth a simultaneous increase of heat may be experienced. A very great increase of solar radiation, however, could not be thus masked in its effects upon the earth.

Although during the historical period there has probably been no sufficient variation in the activity of the sun to produce very serious terrestrial results, yet it is known that the sun-spot cycle is subject to considerable variations, both as regards the length of the periods and the intensity of the forces concerned in the disturbance. The latest maximum of sun-spots in 1883–'84 was a couple of years overdue. What peculiarities may mark the maximum now approaching time alone can reveal. But, at any rate, the known irregularities of the sun suggest a striking resemblance to what we see in some of the variable stars; and it is highly probable that the changes of the latter, except in certain cases where other more satisfactory causes have been inferred, are due to phenomena resembling sun-spots, if not in fact directly analogous to them. Is sun-spottedness, then, a progressive condition; and will our sun in time become, through this cause, variable to the extent shown by many of its compeers in the heavens?

It is true that on account of the remoteness of any calamitous effects resulting from such gradual changes in the sun's condition we can afford to regard them with indifference, so far as the welfare of our race for many thousands of years is concerned; but when we rise to a higher point of view, and put aside merely human measures of time, the question becomes one of deep interest, since it involves the probable ultimate fate of our planet as the scene of the development and achievements of intelligent creatures. Will the earth become a desert like its companion the moon through the exhaustion of its vital forces and the disappearance of its air and water, while the sun yet shines upon it with unfailing splendor; or will the end of terrestrial life be brought about by the agency of the sun itself, either through the failure of the solar energies, or through an overwhelming outburst of them? These questions are not the less interesting, and not the less certain to obtrude themselves, because it is at present impossible for us to answer them. They have also a bearing upon the geological life record of the globe. Already, under the enormous demands for time made by the evolutionary doctrine, geology is asking for far longer periods of stability in the light and heat supplies of the sun than astronomy, also supporting itself upon the principles of evolution, is able to grant. But if the sun has emerged from the stage of a third or fourth type star, and by the gradual elimination of its obstructive envelope has arrived at that point of comparative regularity of radiation in which we behold it, the time

during which it can have maintained the earth in a habitable condition is proportionally shortened, for we can not suppose that animal and vegetable life could be developed under the dominion of a distinctively variable star. The assumption is here made, of course, that a variable star is really a sun and not a cloud of meteorites in collision, or a partially condensed nebula, and that its planets, if it is ever to have any, have already been formed. Progress in the other direction—that is, from the white star toward the red star and variable star stage—would seem to supply longer periods of unvarying solar radiation for the evolution of planetary life, since a sun developing in that way would become a stable radiator sooner than if it had first to free itself from a sheathing of absorbing vapors created, it may be, by its own action at a certain stage of its career rather than left behind as a subsiding remnant of the original nebula.

We have remarked that, so far as the records of human history inform us, the emission of light and heat by the sun has never seriously varied. Yet it has been thought, though the evidence is not clear, that there are geological indications of considerable variations in the amount of solar radiation in past time, and the famous myth of Phaeton driving the chariot of the sun and getting so far out of his road that he endangered the earth and made it smoke with unwonted heat, has often been referred to as a possible tradition of some extraordinary outburst of solar heat within the period of man's existence. The variable character of sun-spot phenomena certainly does not contradict that supposition. The margin of existence is so narrow for many forms of life that no very great change would be required to cause a disaster. Still, notwithstanding the vagaries of sun-spots, and the apparent analogy between the sun and the variable stars, it would not do to assume that the earth is at present in any danger from a changing mood in its great governor and benefactor. So far as positive records serve as an indication of the future, there is every reason to believe that the sun will long continue in its present condition, and that astronomers a million years hence, if some cataclysm arising from ulterior causes does not intervene, may still be found studying the sun, having probably by that time ascertained whether it is getting hotter or colder. But it would not be safe to assume that any astronomers will be left upon the earth five million years hence.

THE inquiries of the British Labor Commission have brought out the fact that some of the workmen believe that the state should by penal enactment prevent all men over sixty years old from working for wages, giving them instead of work a pension. Their theory is that to give work for pay is a benefaction to the community, for which gratitude and a reward are due them.

A CLASSIFICATION OF MOUNTAIN RANGES ACCORDING TO THEIR STRUCTURE, ORIGIN, AND AGE.*

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THE sea, in its vastness, reaching far beyond the encircling flat horizon, is a better symbol of infinitude and of eternity than is the most majestic mountain range, lifting its serrated forehead miles above the ocean-level and seeming almost to pierce the sky. The sea itself, but no part of the land forming its shores, has continued unchanged through the series of geologic eras.

> "Time writes no wrinkle on thine azure brow—
> Such as creation's dawn beheld, thou rollest now."

But on the land, no sooner have the subterranean forces upheaved a mountain, a plateau, a continent, or an island, than the processes of subaërial erosion begin to contend against it. Rains, frost and heat, chemical change, subdue the most enduring and solid rock formations, dividing them with fractures, and pulverizing their masses and fragments to sand and clay, which gravitation by the vehicle of running water carries down and away to the sea, there to find rest until another uplift shall renew the cycle of changes. "The mountain falling cometh to naught, and the rock is removed out of his place."

The form of mountains and of their ranges and systems is due to the combination, in varying ratios, of constructive and destructive agencies. The first only seem necessary; but the second have generally been far more efficient to give the shape and outlines of all our mountains, excepting volcanoes. Constructive forces have done work that may be compared to the quarrying of the block of marble and bringing it to the artist's studio; destructive forces, producing the present mountain forms, as they stand before our vision, have done work like chipping away the greater part of the marble block and chiseling it to the finished statue. It will be convenient to speak of the constructive processes as mountain-building, and of the destructive as mountain-sculpture.

It is from observation and study of the geologic structure of mountain ranges, the diverse rock formations of which they are composed, and their attitude and relationship to each other, that we discover and understand their origin; how, by what agencies, the mountains have been built and sculptured. Structure and origin are thus very intimately connected and demand the same division under classes and types. In this classification, when citing examples of each type, we can commonly note also their geo-

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logic age, or the epochs of deposition of the rocks forming the mountain range, the epoch of their upheaval or successive upheavals, and the subsequent time during which they have been exposed to erosion.

Six classes of mountain ranges may be discriminated which, from predominant features of their structure, may be named as (1) folded, (2) arched, (3) domed, (4) tilted, (5) erupted, and (6) eroded. In each class the present contour of peaks, ridges, buttresses, and slopes has commonly been produced by the destroying frost, storms, and streams; but wherever some special phase of mountain-building is discoverable within the disguise which the superficial transformation has imposed, the mountain range or separate mountain is thereby referred to its constructive type. The last-named class, therefore, is intended to include only those mountains and ranges which owe their prominence to the denudation of an equal or greater thickness of the same rock formations from the surrounding country or from the valleys that divide them from other mountains, while the structure of the masses spared by this erosion does not place them in either of the five preceding classes as areas that have experienced mountain-building or orogenic movements. The sixth class belongs to areas where continent-building or epirogenic movements of widely extended elevation have been followed by so deep erosion that mountains have been made wholly by sculpture. Often the processes of mountain-building have combined in the same range the features which give names to two or more of these classes, but usually there is some chief element in such complex structure, predominantly allying the range with one of the five orogenic types. Faults, as the geologist calls dislocations of the rock formations, where the portion of the earth's crust on one side of a plane of shearing has been borne upward or forward, while the portion on the other side has fallen downward or backward, often complicate each of the six classes of mountain structure; and they are the sole or principal means of formation of the fourth, that is, of tilted ranges.

The plan of this essay is to examine the structure of each class, and to inquire what was the manner of action of the mountain-building or orogenic forces producing each of the five constructive types, and of the continent-building or epirogenic forces producing the broad, elevated expanses from which erosion has formed the sixth type, mountain remnants of destroyed high lands. Examples of each class are described, and the geologic age of their rock formations, of their upheaval, and of the ensuing erosion, is stated so far as it has been studied out, giving thus, in a brief way, both a description and a history of the mountain range or system.

1. FOLDED MOUNTAIN RANGES.—Foremost in their geographic importance, and in the intricacy and significance of their geologic structure and origin, are the mountain belts which consist of folded rock formations. The strata forming the upper part of the earth's crust are bent up and down in long, nearly straight or curving, wave-like ridges and troughs, and where their disturbance was greatest the successive ridged folds are closely pressed together. The waves of the rock structure are then pushed to such steepness that their sides become parallel with each other, and the entire fold is driven forward into an inclined position. The order of the strata on the lower side of the appressed fold is thus inverted; the originally highest and last formed deposits there lie beneath older beds, in an overturned series. Subaërial erosion then wears down the undulations and the crests of the closely folded strata, often planing them off until a long section, crossing mountain ranges, passes from older to newer beds, and onward from newer to older, in several alternations, having throughout the whole a nearly constant steep dip. Owing to the interbedding of hard and enduring sandstone, quartzite, gneiss, and other rock formations, with more easily eroded limestone, shales, incoherent sandstones, or schists, the erosion commonly produces a new topography, making hollows and long valleys where the more erosible beds have been removed, and leaving ridges and mountain ranges of the harder rocks. More than this, when erosion has been continued through very long periods, it tends toward the ultimate result of removing the upward curved or anticlinal portions of the great folds and sparing the originally lower downward curved or synclinal portions, until valleys take the places which were originally occupied by the highest upheavals, while the original troughs, where the rocks were most compacted by pressure, remain now as the principal mountain ridges. Under denudation, the folded mountainous belt fulfills the prophecy, "Every valley shall be exalted, and every mountain and hill shall be made low."

The most perfect type which the world affords of this structure, or at least the example which has been most fully studied as to the age of its strata, the dates of their foldings and upheavals, and the effects of erosion, is the Appalachian mountain system. As made known by the brothers W. B. and H. D. Rogers and by later geologists, a vast series of Palæozoic strata, representing continuous deposition from the early Cambrian to the close of the Carboniferous period, is thrown into many long, steep folds in the Appalachian ranges of Pennsylvania and the Virginias, making the southeast part of this mountain system, and into plateaus and gentle undulations in the Catskill, Alleghany, and Cumberland Mountains, which are its northern and western portions. After

the formation of the coal measures, the thick sediments that had been laid down in the subsiding eastern margin of the Palæozoic ocean, which extended westward over the present basins of the Laurentian lakes and the Mississippi, were compressed into folds and raised to constitute a mountain mass one thousand miles long and seventy-five to one hundred miles wide, with probably much greater altitude than now. During Permian and Triassic time, according to Prof. W. M. Davis, this elevated area was channeled by rivers and finally was mostly worn down to a broad base-level or a moderately undulating expanse. Renewal of elevation, occurring in the Jurassic period, was probably attended with the remarkable overthrust faults, having apparently a maximum extent of about eleven miles of horizontal displacement, which have recently been studied out by C. W. Hayes, similar to the thrust-planes discovered by Peach and Horne in northwestern Scotland. Another cycle of base-level erosion is shown by Davis to have extended from the Jurassic upheaval to the end of the Cretaceous period, reducing the Appalachian Mountains to a lowland tract, in part nearly flat and in part hilly, which he names the Schooley peneplain. This tract, almost a plain at the close of the Mesozoic era, was then a third time upheaved; and the present valleys of the Appalachian belt, divided by very long mountain ridges of uniform height, have been cut by river erosion during the Tertiary and Quaternary eras.

Closely associated with the foregoing are other folded groups and ranges of mountains, which Prof. C. H. Hitchcock has named the Atlantic mountain system, first raised as mountain masses in the Cambrian and Silurian periods, long before the great Appalachian revolution terminating the Coal period. In order from northeast to southwest, this system comprises low mountains in Newfoundland and in the eastern provinces of Canada, south of the St. Lawrence; the mountains of Maine; the White Mountains; the Green Mountains; the Hoosac and Taconic ranges; the Hudson highlands; Schooley's Mountain and other ranges in New Jersey; the South Mountain in Pennsylvania; the Blue Ridge in Virginia; and the Blue Ridge, the Stone Mountains, and the Iron, Bald, Smoky, and Unaka ranges in North Carolina. This mountainous belt, extending nearly two thousand miles, is everywhere characterized by overturned folds, and by intense metamorphism, the sedimentary strata, originally shales, sandstones, and conglomerates, being changed to crystalline schists, gneiss, and granite. Denudation of the Atlantic mountain system, and of lands stretching eastward over part of the present Atlantic Ocean area, supplied the deposits which were upheaved in the building of the Appalachian ranges.

A still older Laurentian mountain system, first upfolded in

the Archæan era, is to-day represented by the Adirondacks, the Laurentide highlands, and the mountains of Labrador, Baffin Land, and Greenland. Asking, then, how the mountain-building forces of eastern North America have been manifested, we see that the upper part of the earth's crust here has been folded by pressure from the Atlantic toward the central area of the continent, exerted during certain epochs of mountain formation, which have alternated with long intervals of repose and of base-leveling by stream erosion. Three chief epochs of orogenic upheaval have produced the intimately blended Laurentian, Atlantic, and Appalachian mountain systems, which geologists distinguish because of their diversity in age and in many of their physical features, but which geographers unite as the eastern mountainous belt of our continent. As a whole, it may perhaps properly be called the Appalachian, or, better, the Appalachian-Laurentide belt.

Other examples of this structure are developed on the grandest scale in the Old World, comprising the Atlas Mountains, the Pyrenees, the Alps, the Apennines, the Carpathians, the Balkans, the Caucasus, the Elburz, the Hindoo Koosh, and the Himalayas, together reaching from the Pillars of Hercules to the China Sea. These complex mountain systems may collectively be called the Alp-Himalayan belt. During the Miocene, Pliocene, and Glacial periods to the present time, compression has been exerted on each side, upbuilding its mountain chains, which cover a length of about eight thousand miles, occupying a third part of a great circle. In North America the Laurentian mountain system belongs to the remote beginning of the geologic record, and the Atlantic and Appalachian systems are very old, having repeatedly been almost base-leveled; but these principal mountains of northern Africa and of Europe and Asia are geologically very new, the highest being still in the growth of infancy and youth. When upward growth ceases, erosion triumphs and by slow degrees sweeps the mountain mass into the sea. The perpetuation of ancient mountain systems has depended on repeated upheavals, and in their present condition they are remnants spared from the erosion of areas lately elevated. Portions of this great Eurasian mountain belt began to be plicated and thrust up long before the Tertiary era, and doubtless some of its mountain systems were comparatively undisturbed during the Tertiary and Quaternary folding and upbuilding of the Alps and Himalayas; but mainly the prominence of the belt is due to the lateness of the plication, and in part to its being now in progress.

Nearly all the principal mountain systems of the world have a folded structure, but in many instances they retain no semblance of their primal undulations and earliest contour. In the mountainous plateau of Scandinavia and its outlier, the Scottish

Highlands, only the bases of the ancient mountains remain. Eroded, perhaps repeatedly, almost to the sea-level, these plicated areas have been again elevated and are now deeply incised with valleys, fiords, and lochs. In the western mountain belt of North and South America a long and eventful history of extended plication and upheavals in many separated geologic epochs is more or less clearly revealed; but the latest accidents befalling this belt during the Quaternary era will call for special description under the fourth structural type, with which the earlier revolutions of this most prolonged mountain chain will be reviewed.

2. ARCHED MOUNTAIN RANGES.—Far less frequent than the foregoing, and indeed known only in parts of the Cordilleran belt of the western United States, is the arched structure, which may be best described in its most typical example, the Uinta range of northeastern Utah. According to Powell's report on the geology of these mountains, a great thickness of many rock formations has been here raised in an arch about one hundred and fifty miles long from east to west and thirty to forty miles wide. The strata range in age from the Archæan and Cambrian to the Cretaceous and Tertiary, and they appear to have reposed horizontally, as laid down in the sea, until the end of the Cretaceous period. The upheaval took place during the Tertiary era, mostly in its earlier portion, and the whole extent of the upward arching was about five and a half miles. Erosion, however, has gone forward during the growth of the arch, so that the highest peaks of the range have an altitude of only about two and a half miles, or thirteen thousand feet. Upon each side of the Uinta arch and about its ends the stratification is steeply inclined and occasionally cut by faults; but higher up the inclination diminishes and the strata extend across the top as a flattened dome, without folding or dislocation.

How were the mountain-building forces applied to form this arch? Its short extent in proportion to its width and the absence of plication make it difficult or impossible to refer it to lateral pressure, which has been regarded as the manner of application of the energy forming the great folded ranges. All the features of the Uinta range, instead, point to upward pressure as the form of mountain-building energy to which its elevation was due. It is very important, however, to note that the process of the Uinta elevation was so gradual and slow that the rivers which flowed across the area before its upheaval were not turned aside, being able to cut down their channels, which in the heart of the mountains are precipitous, narrow cañons, as fast as the elevation progressed. After the consideration of the remaining types of mountain structure, we shall further examine this question of the method and the origin of the diverse manifestations of mountain-building.

Adjacent to the east end of the Uinta arch, two similar but small upthrust mountains were formed at the same time, and repeat the same structural type in its essential features, but they have sharply arched crests, and their longer axes run from north to south, at right angles with the major axis of the Uinta range. These are Junction Mountain, about twelve miles long and four miles wide, and Yampa Mountain, seven miles long and about three miles wide. Both are cut by the Yampa River, flowing directly through them in deep cañons, instead of passing around, thus showing that these very short upthrusts, like that of the larger range, were gradual, not sudden, in their development. The vertical extent of the upward arching of the strata to form each of these mountains, counteracted meanwhile in large part by denudation, is believed to have been somewhat more than two miles; and this great elevation of so small areas was yet not too rapid to permit the river to keep pace with it in the downward cutting of its cañons.

3. DOMED MOUNTAINS.—The structural type here designated is exemplified by the Henry Mountains in southern Utah, which have been elaborately studied by Gilbert. These mountains were formed as dome-shaped or bubble-like but gigantic uplifts of previously horizontal Carboniferous, Jura-Trias, Cretaceous, and Tertiary formations, by the volcanic injection of immense lenticular masses of porphyritic trachyte between the strata of the series. The injected lava mass is named by Gilbert a laccolite (cistern-stone). Whereas in the first type of mountain structure the formerly horizontal strata were thrown into folds, and in the second were curved upward in great arches, they here were simply lifted quaquaversally, as a geologist would say, in vast domes. Mount Ellsworth, the most southern of the Henry Mountains, was lifted by only one laccolite; Mount Holmes, the next northward, by two; Mounts Hillers and Pennell, next in order to the north, each by one large and several smaller laccolite intrusions; and Mount Ellen, the most northern mountain of this group or range, was puffed up by many, perhaps thirty, of these cistern-like masses of lava. The Henry Mountains extend about thirty-five miles from south-southeast to north-northwest, with a width of five to ten miles; and their highest summits rise about five thousand feet above the plateau of their base, or eleven thousand feet above the sea.

From these summits the view embraces within distances of fifty to one hundred and twenty miles northward, eastward, and southward, no less than five other mountain groups of this type, namely, the Sierra La Sal, the Abajo, La Lata, Carriso, and Navajo Mountains; and two hundred miles to the east the Elk Mountains of Colorado belong to the same class. The Henry Mountains and these other groups were all probably uplifted near the middle of

the Eocene period, the first of the three divisions of the Tertiary era. They were contemporaneous with the growth of the Uinta range and the Junction and Yampa Mountains; but the Henry structure represents sudden lifting by the energy of volcanic inflows of molten rock, while the Uinta structure, as we have seen, represents a very gradual upheaval. The two can not be referred to the same means of elevation, though their more remote causes were doubtless nearly related or identical. No laccolite mountains are known in other countries, and here they are found only in the region of plateaus which is intersected by the cañon of the Colorado.

4. TILTED MOUNTAIN RANGES.—Next to the west of the Colorado drainage area is the Great Basin of interior drainage, which returns all its rainfall again to the clouds by evaporation. Were the lakes of this arid region to grow by increased rainfall until they should flow across the lowest points of their water-sheds and send streams to the ocean, two of them would be similar in area to the Great Lakes of the St. Lawrence. Twice during the climatic changes of the Glacial and Post-glacial epochs, these two lakes, named Bonneville and Lahontan, have so risen nearly or quite to overflowing, whereas now the former is represented by Great Salt Lake in Utah, and the latter by Pyramid and Winnemucca Lakes, with others in Nevada. Close east of Lake Bonneville rises the Wahsatch range, and west and southwest of Lake Lahontan is the Sierra Nevada, both of which are examples of tilted mountain ranges. The Wahsatch has been elevated along fault lines which form its western boundary, adjacent to the area of Lake Bonneville and the present Great Salt Lake. It is an immense mountain mass which has been tilted by upheaval of its western border and sinking of its eastern portion. The Sierra Nevada, on the other hand, has been upheaved along fault lines bounding it on the east, and is concisely described as principally a single great block of the earth's crust, about three hundred miles long from north-northwest to south-southeast, and fifty to seventy miles wide, tilted by elevation of its east side and depression of its west side. Between these grand mountain ranges which look toward each other on the east and west limits of the Great Basin, many minor ranges occur, trending from north to south, all of which have the same structure and origin through faulting and tilting, so that this is called by Powell the Basin type of mountain structure.

The great disturbances producing the Basin ranges were of late geologic date, in the early part of the Quaternary era. The resulting mountain ranges are still very young, geologically speaking, and therefore some of them rank among the most prominent on this continent. During more remote periods doubtless

many ranges in various parts of the world have been formed in this way, their sites being now marked by profound faults which are clearly traceable, though the tilted mountains of the upheaved side of the faults have long since passed through youth, maturity, and old age, leaving no topographic evidence of their former existence.

Many stages of mountain-building have left their impress on the great Cordilleran belt of the western part of the United States and the Dominion of Canada. The Gold and Selkirk ranges of British Columbia, according to Dr. George M. Dawson, consist of Archæan, Cambrian, and Silurian formations, which were pushed up into mountain folds before the close of these very ancient divisions of geologic time. The auriferous slates of the Sierra Nevada, as Becker has shown, were similarly built up in a folded mountain range at the close of the Gault epoch in the Cretaceous period. During the ensuing long lapse of time to the end of the Tertiary era, this precursor of the Sierra Nevada range had been worn down to only a moderate elevation by the gnawing frosts, heat, rains, and running streams; but the beginning of the Quaternary era, according to Le Conte and Diller, brought revolutionary changes. The previously base-leveled region which now forms the Great Basin was then upheaved as a high plateau; intense volcanic activity was manifested in many parts of this area, and especially from the vicinity of Lassen Peak and Mount Shasta northward to the Columbia River and eastward along the Snake River to the Yellowstone National Park; and long faults, running mostly from north to south, divided the distended region into a multitude of orographic blocks, which, being soon allowed to sink, became tilted in their subsidence and form the present Basin ranges.

If we attempt to correlate these events with the Quaternary glaciation of the northern part of our continent, they seem to have been contemporaneous with the maximum extension of the ice-sheet of the first Glacial epoch. The ice accumulation I have attributed, on evidence derived from fiords and from river-channels now deeply submerged by the sea, to former great elevation of the glaciated areas, probably three thousand to four thousand feet higher than now. But the glacial and modified drift show that toward the end of each of our two principal Glacial epochs the land on which the ice lay was depressed nearly to its present level or in part lower. This depression of the earth's crust I believe to have been caused by the vast weight of the ice-sheets; and, in the first Glacial epoch, we have the correlative somewhat sudden elevation of a contiguous area, with outpouring of lava and formation of tilted mountain ranges, in the Great Basin and north to the Columbia. During the long interglacial epoch very

thick subaërial deposits, called by Russell adobe, were supplied by denudation of the mountains and spread on the lower parts of the Great Basin and in the San Joaquin Valley; and the subsequent two flooded stages of Lakes Bonneville and Lahontan belong apparently to the second Glacial epoch and to a later or third epoch of glaciation in the northern part of the Cordilleran region.

Extending our view to embrace the entire belt of which the Rocky Mountains, Sierra Nevada, and Coast Range are parts within the United States, we see that it forms the western side of both South and North America. Its length from Cape Horn to Alaska is about ten thousand miles of a great circle, from which the irregular course of the chain is nowhere widely distant. These complex mountain systems, including the Andes, the mountains of Central America and Mexico, the Rocky Mountains and parallel ranges west to the Pacific, and the Alaskan mountains, may be together named the Andes-Cordilleran belt. In Bolivia and Peru the highest portions of the Andes are found by David Forbes to be folded Silurian strata, which are so associated with Devonian, Carboniferous, and Permian formations as to imply that the principal epoch of mountain plication there, as of the Appalachian system, was at or near the close of the Palæozoic era. But later epochs of plication are also recognized in portions of the Andes, as likewise in the rocks of the Sierra Nevada, the Wahsatch, and the Coast Ranges, in the western United States. Indeed, the last-named range, and the range which culminates in Mount St. Elias, the former stated by Whitney to contain infolded Pliocene beds, and the latter found by Russell to consist of Pliocene or early Quaternary rocks, were formed by very late mountain-building, perhaps correlative, like the faulting and tilting of the Basin ranges, with great movements of the earth's crust producing and accompanying glaciation. The present height of the Andes, as of the Appalachian, Atlantic, and Laurentian mountain systems, and the Cordilleran ranges of the west part of this country and Canada, must be ascribed to Tertiary and Quaternary upheavals of this belt, portions of which had long before and at different times been folded and raised to mountain heights, but afterward had suffered erosion almost or quite to a base-level.

5. Erupted Mountain Ranges.—Volcanic action has often been developed on a grand scale along the deep fissures and fault-planes which border and intersect tilted mountains and plateaus, as notably in the Andes and in Mexico, where it has built up very conspicuous volcanic cones of outpoured lavas and ejected blocks, bombs, lapilli, and ashes. Often, too, prolonged fissures, which may intersect each other (as in the Hawaiian Islands), reach down through the earth's crust to lavas that well up and build mount-

ain masses and plateaus, while the crust segments have been only slightly tilted and sometimes lie wholly beneath the sea-level. Such eruptions form the Cascade Range, the mountainous plateaus of Iceland and the much-eroded Färöe Islands, the Deccan plateau in India, the volcanic chains of the Sunda, Kurile, and Aleutian Islands, and the Hawaiian Island belt.

The Cascade Range is a typical example of this class, having an extent of more than 500 miles from south to north across Oregon and Washington, showing a thickness of nearly 4,000 feet of lava where it is cut through by the Columbia, and bearing here and there volcanic peaks which rise to altitudes 10,000 to 14,000 feet above the sea. The eruptions producing this range took place during late Tertiary and early Quaternary time, being contemporaneous with the faulting and tilting of the Basin ranges, the Wahsatch, and the Sierra Nevada, and with the folding and upbuilding of the Coast Range. As Jamieson and Alexander Winchell have well suggested, the outpouring of the vast lava floods of the Cordilleran belt in the United States, a portion of which forms the Cascade Range, was probably in large part or wholly dependent on movements of elevation and subsidence of the adjacent glaciated area. Another erupted range, on a smaller scale, but very interesting in its details as described by Russell, belonging to the Quaternary era, and partly to the recent epoch, lies close south of Lake Mono, in California.

6. Eroded Mountain Ranges.—The form and contour of nearly all mountains, excepting volcanic cones, have been given to them by the sculpturing agencies of subaërial denudation. This is true of each of the foregoing classes, where mountain-building energy has supplied the mass, but erosion has shaped the slopes, ridges, and peaks, the ravines and valleys. These five classes of mountain ranges have been sculptured by erosion, where previous mountain-building has raised limited areas to an exceptional altitude. But besides these orogenic upheavals, there have been broader uplifts of the whole or large parts of continents, which Gilbert and White have called epirogenic movements. The sixth class of mountain ranges, here to be noticed, is distinguished from all the preceding by its comprising mountains which owe their origin to no definite mountain-building process, being simply remnants of extensive areas which have been uplifted by epirogenic energy as great plains and since have been deeply eroded.

The plains which slowly rise from the Mississippi Valley and Manitoba westward to the foot of the Rocky Mountains afford examples of this type of mountain structure. Perhaps the most striking is the range of the Crazy Mountains in Montana, which lies immediately north of the Yellowstone River near Livingston, and

is conspicuously seen from the Northern Pacific Railroad. These mountains trend slightly west of north, and extend about forty miles with a width of fifteen miles, attaining an elevation of 11,178 feet above the sea and 5,000 to 6,000 feet above the prairies at their base. Their structure has been thoroughly studied by Wolff, who finds that they consist of late Cretaceous strata, soft sandstones, nearly horizontal in stratification, intersected by a network of eruptive dikes. The more enduring igneous rocks have preserved this range, while an average denudation of not less than one mile in vertical amount reduced all the surrounding country to a base-level of erosion. The Highwood Mountains, about 25 miles east of Great Falls, Montana, having a height of 7,600 feet above the sea, or about 3,500 feet above their base, are described by Davis as displaying the same structure, and therefore similarly testifying of great denudation. This erosion of the Great Plains was probably in progress during the whole Tertiary era. Around Turtle Mountain, on the boundary between North Dakota and Manitoba, its amount was not less than 500 to 1,000 feet.

Original epirogenic uplifting of these plains took place at the end of the Cretaceous period, or during the early part of the Eocene. Thence onward through the Tertiary era, rains, creeks, and rivers were reducing this region nearly to the sea-level, excepting remnants like the Crazy, Highwood, and Turtle Mountains, which were being sculptured approximately to their present form. But the Tertiary era seems to have been terminated and the Quaternary ushered in by a new epirogenic differential uplifting of this continent, causing the accumulation of the ice-sheet of the first Glacial epoch. The time of great elevation initiating the Ice age, and the ensuing long interglacial epoch before the second glaciation, appear to have permitted rivers in North Dakota and Manitoba to wear away a considerable part of the Tertiary base-leveled plain, from its former eastern margin to the remarkable escarpment, in part a small eroded mountain range, of the Pembina, Riding, and Duck Mountains and the Porcupine and Pasquia Hills, which form the west border of the Red River Valley plain and of the lowland with large lakes in central Manitoba.

Reviewing this classification of mountain ranges for the purpose of discovering what elements of diversity and of unity characterize the manifestations of mountain-building energy, we see this to be of two kinds, the second being presented under four phases. The first kind of mountain-building energy, producing folds, is evidently lateral pressure, and is ascribed by geologists and physicists to the contraction of the earth's mass by its secular cooling, with resulting adaptation of the rigid outer part of the crust to the shrinking interior. The second is energy acting ver-

tically upward, which has produced the four other types of constructive mountain ranges and masses by diverse phases of its manifestation—namely, the slow arching of limited areas, as the Uinta, Junction, and Yampa Mountains; the sudden volcanic lifting of the laccolite mountains; the upheaval and subsidence, with faulting and tilting, of the Basin ranges; and the outpouring of lava, as in the Cascade Range. Each of these four phases of vertically acting energy depends upon a viscous and plastic (neither solid nor perfectly liquid) condition of the earth's interior. Greater pressure of some portions of the crust than of others upon the plastic interior would induce each phase of upward energy in mountain-building. Where isolated blocks of the crust yielded slowly to the resulting quasi-hydrostatic pressure of the interior, mountains of the Uinta type were formed; but large areas, as the Great Basin, being swelled upward and anon subsiding, as the interior pressure increased and diminished, have become marked by tilted mountain ranges. Where the relations of intense heat, immense pressure, and chemical influences, with presence of water or its further ingress, have allowed portions of the interior, often of great extent, to become liquid lava, its extravasation by the same pressure has formed laccolite mountains and erupted mountain masses, while many volcanic cones have been mainly built up of fragments of solidified lava, much of it so fine as to be called ashes, explosively ejected.

In an appendix of Wright's Ice Age in North America, I have pointed out the source of the relationship by which these two kinds of mountain-building energy are united, both being caused by the earth's contraction in cooling, and the second or upwardly acting kind of energy being dependent on the first in the intermittent and occasional relief of stress of the earth's crust by its folding along the great orographic belts. Between the epochs of mountain-building by plication, the diminution of the earth's mass produces epirogenic distortion of the crust, by the elevation of certain large areas and the depression of others, with resulting inequalities of pressure upon different portions of the interior; and these effects have been greatest immediately before relief has been given by the formation of folded mountain ranges. There have been two epochs pre-eminently distinguished by extensive mountain-plication, one occurring at the close of the Palæozoic era and another progressing through the Tertiary and culminating at the beginning of the Quaternary era, introducing the Ice age. During the last, besides plication of the Coast Range, of the Alps, and the Himalayas, a very extraordinary development of tilted mountain ranges, and outpouring of lavas on an almost unprecedented scale, have taken place in the Great Basin and the region crossed by the Snake and Columbia Rivers. With the cul-

minations of both of these great epochs of mountain-building, so widely separated by the Mesozoic and Tertiary eras, glaciation has been remarkably associated, and indeed the ice accumulation appears to have been caused by the epirogenic and orogenic uplifts of continental plateaus and mountain ranges. Since the disturbances, with glaciation, closing Palæozoic time, the same combination of events has not recurred until the Quaternary era, which is not only exceptional in its accumulation of ice-sheets, but also in its numerous and widely extended movements of elevation and subsidence, and in its mountain-building and renewed upheavals of formerly base-leveled mountain belts. The earth's surface is probably now made more varied, beautiful, and grand by the existence of many lofty mountain ranges than has been its average condition during the previous long eras of geologic history.

MUSICAL INSECTS.

By HERR R. FRANCHESCHINI.

IF we would hear the children of the sun, we must shut the door of our prosaic room behind us, and hurry out before the coming on of dusk to the pond, into the green field, on the moor, to the edge of the wood where life in the double form of animal and plant unfolds itself without restraint. From up in the air, from plants, flowers, grass, holes in the ground, and the moisture of puddles, come a chirping and rattling, a humming and buzzing, a piping and singing of the host of winged and wingless creeping and hopping insects. Let us guard our steps. Near us a musk-beetle is groping with his long, knotty feelers along the bark of a willow tree. The shrill tone of his chirp strikes upon the ear; and if we are gifted with musical sense enough we may succeed in hitting the key-note of his register. We need only use our chamber-tone, the treble A, or any other note easy to whistle, in order to determine from it the pitch of the beetle's song. We shall find then that he has the highest-pitched voice in all Nature's concert—the third octave of D. From the distance comes a humming which is related to that chirping as the alto to the treble. It is the sound of the vibrating wing of the moss-bee. The buzzing bass of the bees and wasps is about an octave lower than our chamber-tone A. Within this melodic compass, or the musical space of three octaves and a quarter, lie the voices of all the other crawling six-footed symphonizers. How is all this music produced? Men and the higher animals have lungs—the bellows; a windpipe; a larynx, the real sounding instrument; and, as mouth-piece, the hollow of the throat and mouth. How can in-

sects, too, execute vocal music? The answer is simple: no insect has what we in the proper sense call a voice. They produce their music either like our bumble-bee, by the mere vibration of their wings, or they have some special apparatus which they adapt to musical efforts, the peculiarities of which we are about to learn from some of them.

As we continue our walk, our feet, treading down the grass, cause a lively disturbance, like that which Gulliver raised among the Lilliputians. Every sort of frightened thing, large and small, hops up and down in front of us, behind us, to the right and left. But, out of the confusion of sounds that accompany the disturbance, there strikes upon us, over-sounding all, a sharp rattling—every child knows the musician—the green jumper of the meadows, the grasshopper. What is the instrument that this animal plays upon? The grasshopper is a real fiddler. To satisfy ourselves of this, we have only to catch one and examine him closely, to find that he carries the instrument on which he plays upon his thigh. In our picture (Fig. 1) the inner side of the grasshopper's thigh is represented as turned toward us, and over it is drawn a curious skin. If we bring a section of this skin under a microscope

Fig. 1.—Grasshopper's Leg (magnified three times).

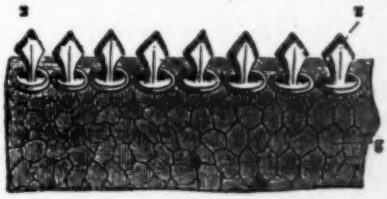


Fig. 2.—Toothed Skin of the Grasshopper's Leg (magnified one hundred times).

magnifying about a hundred times, we shall perceive that the cellular tissue of which it consists is furnished with several small teeth (Fig. 2). They are not much longer than a hair is thick, but there are eighty or ninety of them. This system is the grasshopper's fiddle-bow. The insect has other peculiar formations on each wing; these, however, have no teeth, but are even, and project as an edging along the wing. When the grasshopper would make music, he rubs his fiddle-bow rapidly backward and forward over this process, and there arises the well-known rattling sound, such as one can produce with a bow upon loosely strung violin-strings. The tone, which is strengthened by the action of the wing as a resonance membrane, is not the same with every individual. We hear, sometimes the first, sometimes the second violin, sometimes the bass-viol; and Handel seems to have had the last especially in his mind when, in his Oratorio, Israel in Egypt, he attempted

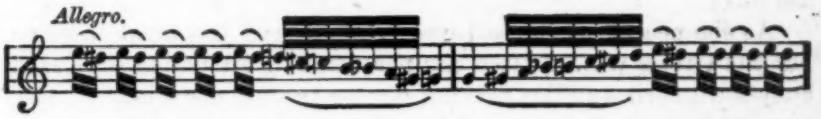
to represent the rushing of the swarms of locusts which afflicted the Nile country as the seventh plague, by a principal viola.

FIG. 3.—CICADA.

Several other species of insects have apparatus for producing sounds similar to that of the grasshopper, or modifications of it. Of a different type is that with which the cicadas (Fig. 3) are endowed—the only creatures of this class which have vocal apparatus analogous to those of the higher animals. Only the males of this family are singers, for which the Greek poets called them happy because their females were dumb. With the ancients, a cicada sitting on a harp was the symbol of music. A pretty fable tells of the contest between two cithara-players, in which the curious event happened that when one of the contestants broke a string, a singing cicada sprang on his harp and helped him out so that he gained the prize. The Greeks, who shut the insects in cages so as to be sung to by them in their sleep, were at odds concerning the nature of their singing apparatus; and the controversy among naturalists on the subject lasted till very recently. The zoölogist H. Landois, who investigated the difficult subject of animal sounds with ceaseless industry and great skill, was able to give a satisfactory solution to the question. According to his research, the case is one in which the sound is really made by air circulating through passages in the interior of the body. Every insect's body is penetrated by a system of breathing-tubes or tracheæ which open at places on the surface. The openings are called stigmata. This system of breathing-tubes, through which the air is inspired and expired, takes the place of the lung of the higher animals. Landois discovered them in very obscure parts of the cicada, and found that they form a kind of windpipe representing the actual tone-factory of the animals. This air cavity is, as the picture (Fig. 4) shows, not quite open, but has only a narrow cleft (*sp*), through which the air goes in and out. The cleft is formed by two stretched membranes (*sa* and *sb*), which vibrate when the air passes through. They serve, in fact, a like function with the vocal cords of our larynx. They lie, besides, opposite a large cavity over which a folded membrane is stretched like a drum-head upon a hard

FIG. 4.—TONE APPARATUS OF THE CICADA (magnified thirty times).

ring, and which, when the vocal cords begin to vibrate, vibrates with them and serves as a resonance apparatus. Although there is no real voice, which with us is inseparable from a mouth, we can say that the cicada comes nearest among insects to having such a gift There is a curious relative of our cicada in America, which in its larval condition exhibits a phenomenon that nothing else is like. The larva lives in that form fully seventeen years under ground before it assumes the shape of a perfect insect. It has been called by the characteristic name of the seventeen-year locust. The voice of this locust was heard on board the Beagle, in which Darwin made his famous voyage, an English mile off. Its song is essentially a trill of the treble E with D sharp, then a run down the chromatic scale and rapidly up again, about such a strain as one would play if he slipped his finger up and down the string of a violin while drawing the bow over it. The musical reader may gain from the following an idea of the talent as a composer, and of the song of this locust:



With most musical insects there is no special apparatus for the production of tones. They simply combine the useful with the agreeable. The wings that bear them through the air also make the sound-waves. The only remarkable thing is, that the flying-tones thus produced are so different in single kind. The wings of the bee, for example, vibrate four hundred and forty times in a second—the same number of vibrations as in our normal tone; it is the music-master, and is the cleverest and best esteemed of insects. In other bees, as the female bumble-bee, the wings vibrate eight hundred and seventy times in a second, and sound the treble A, an octave higher than the bee. Marey, who has succeeded in photographing the flight of birds, has also found an ingenious method of determining the number of vibrations of insects' wings. He fixed a fly so that the extreme tip of its wing touched a soot-blackened cylinder, which could be turned by clock-work upon its axis. Every stroke of the wing made a faint but perceptible mark, by means of which Marey was able to determine that the fly made three hundred and thirty wing-beats in a second.

As we sit at night by the lamp, there arises suddenly a loud humming tone, alternately swelling to considerable strength and diminishing till it is barely heard, until the musician, a large blue-bottle fly, to our annoyance darts humming against our cheek or hand, or precipitates himself into the lamp. Every reader has

had occasional opportunities, of which these are instances, to enjoy the study of such examples of the capacity of insect sounds to make music.—*Translated for The Popular Science Monthly from Ueber Land und Meer.*

ESKIMO BOATS IN THE NORTHWEST.

By JOHN MURDOCH.

AS we came in sight of the Eskimo village at Cape Smyth, late in the afternoon of September 8, 1881, some one called out that a boat full of natives was coming off under sail to meet us. We all rushed to the rail, eager for the first sight of our future neighbors, and saw running down before the wind a large boat shaped like a fisherman's dory, with one mast and a single square sail, of blue drilling, which looked almost black through the mist.

As she neared us the sail was taken in and the mast lowered, but the strong wind drifted her past us, and all hands were soon busy with their paddles driving her up against the wind till they were near enough to catch a line thrown from the schooner and gradually haul the boat alongside. A strange party they were as their boat was towed astern, dancing in the waves, while we crowded to the taffrail to look at them, and hail them with the few words of Eskimo that we knew.

All were dressed in deer-skins, over which many had drawn water-proof hooded frocks made of the entrails of the seal, while others wore outside gay frocks of calico, fluttering in the strong breeze which blew back the long hair from the men's foreheads.

All were grinning and shouting, and very strange to us looked the curious *labrets* or lip-studs which all the men wore at the corners of the mouth, like a couple of large sleeve-buttons stuck through holes in the under lip.

But the strangest of all was the boat they were in. About thirty feet long and six feet in the beam, she was merely a skeleton of wood covered with skin tightly stretched across this frame. This was the big family boat, used for traveling and the chase of the whale and walrus, the *umiak*. Like all the Eskimos who have boats at all, and but very few do not use them, the Eskimos of Point Barrow and Cape Smyth use two kinds of boats: one called an *umiak*, a large open boat capable of holding fifteen or twenty people; and the other called a *kayak*, which holds only one man, and is very like a racing shell boat or one of our "Rob Roy" canoes, which, indeed, were modeled after the Eskimo *kayak*. It is narrow and sharp, and decked all over except a round hole in the

middle where the man gets in and sits with his legs under the forward deck.

All the Eskimos, except perhaps some of them who live in the wooded regions of southeastern Alaska, who are said to use birch-bark canoes like the Indians, cover their boats with the skins of marine animals, using the skins of the larger seals for the *umiak*, and those of the small seals for the *kayak*.

It is no small undertaking for a man at Point Barrow to collect wood enough for the frame of an *umiak*, for he has only the drift-wood on the beach to select from, and the larger parts are often elaborately pieced together. When a suitable stick for making a stem or stern-post is found, the finder marks it for his own—and it is the unwritten law of the community that such marked property shall be respected—and when he has leisure goes out with his little adze and works away at it on the beach till he has hewn it into shape before he brings it home.

When he has at length collected all the pieces for the frame, he begins to put them together, without using a single nail in the whole structure. The heavy parts of the frame are neatly mortised together and secured with wooden pegs, while the lighter parts, such as ribs and gunwales, are secured by regularly sewing them with long, thin strips of whalebone, which are run through holes drilled in the two parts to be united.

The following pieces make up the frame of the *umiak:* Along the middle of the bottom runs one long timber, to the ends of which are scarfed the stem and stern-post, made of natural knees, and slanting so that the top of the boat is longer than the bottom. The top of each part is widened into a square block. This makes a high seat for the steersman in the stern and a sort of shelf in the bow. On each side of the bottom is another stout strip of wood, deeper than the keel, which make the edges of the flat bottom, being bent in and scarfed to the stem and stern-post, but spread apart amidships by the floor timbers, which are laid across the keel inside, but mortised into these side strips. There are a dozen or fifteen floor timbers, longest, of course, in the middle of the boat.

From the side strips rise fifteen or twenty pairs of ribs, fastened on with lashings of whalebone. These slope out a good deal amidships, but grow more nearly vertical toward the bow and stern. On the ends of these ribs are lashed the gunwales, round poles about two inches in diameter, running from bow to stern on each side. These run out beyond the stem and meet in a point, but only project a little beyond the stern-post. Along the ribs inside, about half-way down, is fastened a stout strip of wood on which the seats or thwarts, seven or eight in number, are secured, and to strengthen the frame still more another strip is fastened on outside of the ribs.

When these pieces are properly put together we have the framework of a long boat, with a broad, flat bottom, sharp ends, and flaring sides, with a good deal of "sheer" to the gunwales—that is, with the edge of the boat running up at the bow and stern. To cover this frame they sew together, with an ingenious water-proof double seam, skins of the walrus or the great bearded seal which have been deprived of their hair and dressed with a little of their natural fat, so that they are quite water-proof.

Skins of the bearded seal make the best boat covers, and six good-sized ones are enough for one boat. When the cover is ready it is thoroughly wet and stretched over the frame, the edges being drawn over the gunwales and laced to the strip which supports the seats. Of course, when the skin dries, it shrinks as tight as a drum.

To propel these boats they have a square sail, used only with a fair wind, broad-bladed paddles, and ridiculous little narrow oars, which the women pull with great vigor, but to very little purpose, never keeping time or stroke. The mast stands on one of the floor timbers nearly amidships, and is held up wholly by four stays, two forward and two aft. When the sail is not in use, mast and all are taken down and laid in the bottom of the boat. In traveling along the shore, to save the trouble of paddling, they often harness up three or four dogs and make them trot along the beach, drawing the boat by a long tow-line.

In these boats they chase the walrus, the white whale, and, most important of all, the great "bowhead" or polar whale, from which come the whale oil and whalebone of commerce. In them, too, they make long journeys along the coast in summer, carrying their tents and all their household goods, and sometimes go two or three hundred miles to trade with other Eskimos.

This boat is in no way exclusively a "woman's boat," as it is in Greenland, though the women use it as well as the men, but it is the boat for general use. Nearly every head of a family, unless he is very poor indeed, owns an *umiak*.

In winter the leather cover is removed and put away in a place of safety, and the framework carefully laid up, bottom up, on a special scaffold out of reach of the dogs.

Though the *umiak* is not a "woman's boat," the *kayak* is the man's boat *par excellence*. The Point-Barrow Eskimos, however, do not use *kayaks* as much as some others, especially the Greenlanders. All the men, however, and most well-grown youths own *kayaks* of very good model, and can manage these ticklish craft very skillfully, though they can not compete with the Greenlanders.

Kayaks are mostly used during the summer journeys and for pursuing swimming reindeer and wild fowl on the lakes and riv-

ers. These canoes are very narrow and easily capsized. One which we brought home, and which is now in the National Museum at Washington, is nineteen feet long with only eighteen inches beam, and is just deep enough to hold a man's legs under the deck, which is arched for a short distance forward of the hole. It weighs only thirty-two pounds. The framework of the *kayak* is very light. The stoutest of all the parts are two strips or gunwales, one on each side, about three inches wide and half an inch thick, kept apart by slender deck-beams, which are longest, of course, in the middle of the boat. The ribs are hoops bent into the shape of the letter U, and there are forty or fifty of them mortised into the lower edge of the gunwale, while they are kept in place by slender strips of wood lashed along outside of them from stem to stern. A stout deck-beam across the back of the hole for the rower to lean against and a hoop round the edge of the hole complete the frame of the boat. It is all fastened together, like that of the *umiak*, with wooden pegs and lashings of fine whalebone. Such a boat is covered with five or six skins of the smallest seal, carefully dressed with the hair and black epidermis or outer skin removed. These skins when freshly prepared are of a beautiful cream-white color, which soon turns, however, to dull yellow. These six skins are sewed together side by side, the head of one skin to the tail of the next. Then the cover is thoroughly wet, the boat is laid down on it, and the edges of the cover stretched up over the deck as tightly as possible and sewed together in an irregular seam, running lengthwise along the deck. Finally, the edges round the hole are stretched over the hoop and firmly laced with a thong. This finishes the boat, except for making some loops on the deck fore and aft to hold spears and such things, or whatever load the man may wish to carry.

When a Point-Barrow Eskimo is simply traveling along and does not care to make any great speed, he uses an ordinary paddle with one blade, like those used in the *umiak*, but somewhat lighter. As he has to sit in the very middle of the boat, he can not use this as an Indian would, wholly on one side, driving the boat ahead with straight strokes and overcoming the tendency of the canoe to go off to one side by feathering his paddle in the water or by an outward sweep of the blade. First he makes three or four strokes, say, on the right side, and then, as the boat begins to sheer off to the left, he lifts the paddle out of the water and makes three or four strokes on the left side till she begins to sheer to the right, and so on. They do this pretty skillfully, so that the boat makes a tolerably straight "wake," and goes through the water at a pretty fair rate, but, of course, can make no great speed.

When the time comes for hurry, out is drawn from under the deck the double-bladed paddle, such as we are all familiar with from the writings of Captain Ross and Captain Parry, Dr. Kane, and all the explorers who have visited the Eskimos of the eastern regions. This is about six feet long and has at each end a broad, oval blade, far more serviceable than the narrow oar-blades of the eastern *kayak* paddles. The man grasps this by the middle and dips each blade alternately, regulating the force of his strokes so that the canoe goes straight through the water without veering to right or left. With the double paddle the *kayak* can be made to fairly fly through the water.

A reindeer caught swimming in a lake (the deer often take to the water in summer to escape the plague of gnats and gadflies) has little chance of escaping. The swift *kayak* soon overtakes him. The hunter has already pulled from its loop on the forward deck one of his pair of light lances and has it lying loose on deck, the butt resting on the loop in easy reach. As he ranges alongside his victim he catches it up—a quick downward thrust, and the deer floats a lifeless carcass.

It requires no small skill to manage one of these little craft without upsetting, but the boys begin to learn at an early age, so that balancing grows to be a second nature, and the *kayak* man is as much a part of his boat as a good rider is of his horse. Getting into a *kayak*, even, is an art in itself. I once watched a couple of young fellows launching their boats in the lagoon close to our station. A place was selected where the bank was steep, but not high, say about a foot above the water, while the water was just about deep enough to float the *kayaks*. Then the boats were carefully laid in the water alongside of the bank—it would not do to shove them in over the gravel or allow them to scrape on the bottom, they are so delicate—and held in place by sticking down the blade of the paddle into the gravelly bottom on the outer side of the canoe. Balancing himself by holding on to the handle of the paddle with his left hand, each man cautiously lifted his left foot, and wiping it perfectly clean of sand and gravel with his disengaged right hand, carefully stepped into the canoe. The right foot was then raised with equal care, wiped, and inserted into the hole.

Still balancing himself with the paddle, each man adjusted his clothing, carefully sat down, thrusting his legs under the forward deck, and settled himself in position. A gentle shove-off from the shore, a stroke or two of the paddles, and they were off.

The Eskimos are always very careful to avoid getting any sand into either kind of boat, for it works down among the timbers where it can not be cleaned out, and, gradually getting between the skin and the framework, soon cuts through the former.

Both kinds of boats are always drawn up out of the water, except when in actual use, and the *kayaks*, like the *umiaks*, are always stripped for the winter.

In summer the men often make quite long excursions across the country after reindeer, traveling mostly on the lakes and ponds, crossing from lake to lake with the *kayak* carried on one arm, which is thrust into the hole up to the elbow, with the hand grasping the frame inside. The trading-parties that go east in the spring start before there is any open water along the shore at Point Barrow, and travel along the level shore-ice with the *umiak* lashed to a flat sled drawn by the dogs and all the men and women. Tent, *kayaks*, and all the baggage of the party are loaded into the *umiak*, and so they travel on till, in about two days' journey from the Point, they find the open water which has come down from the great rivers. Then they land the sledges, to be picked up on their return in the autumn, launch their boats, and proceed on their journey by water.

The *umiaks* are first launched about the middle or end of April, when they are dragged on sledges out over the ice to the off-shore open water for the spring whaling. They are constantly in use from that time, whenever the ice will permit, till well into October. The *kayaks* are seldom brought out till the ponds are free of ice—about the 1st of July—but the middle of October generally sees all boats of both kinds laid away for the season.

TAKE CARE OF THE BIRDS!

By Dr. KARL RUSS.

ON an unprejudiced view of the matter, we may well be surprised that a barbarity so foreign to the aspiring tendencies of our age as the destruction of birds should continue; that exhortations to protect them are still necessary; and that active harboring and care of them are not matters of course. There are special causes for the lamentable existing conditions, but a wide survey is necessary to the full understanding of them. If we seek for the causes of the lessening numbers of our wild birds, including the finest and favorite singers, we shall find that they are many and interwoven. Foremost among them are the conditions of modern cultivation. When denudation is the rule in forestry, and the whole growth is cut away with all the old and hollow trees and those that were rich in knot-holes; when agriculture, making the smallest spot of ground productive, roots out stumps and hedgerows, dries up the swamps, drains the larger ponds, and

regulates and straightens the streams, clears the shrubbery from pastures and meadows and groves, and trims gardens and orchards with a view to the largest crops, the birds can find no homes or nesting-places, and of course can not thrive.

In our neglect of care for birds we have failed to keep in check their natural enemies, which are able to do relatively more damage than ever before. These include four-footed beasts, birds of prey, thieving birds, and our own domestic cats and dogs, with rats; to which may be added the hardships of weather, that bear more severely upon birds than in former times, because of the removal of the sheltering woods under which they could once cover themselves, and the modern bird-killing inventions of telegraph wires and electric lights.

The capture of birds for pets is a factor of a little importance in promoting their disappearance; hunting them as game is a more important one; while the destruction of birds for the sake of their feathers, whereby women may gratify their desire for show, has reached a frightful extent.

Before considering what measures may be taken to obviate the danger of extermination to which birds are exposed, it is proper to inquire what these creatures signify in our economy, and whether their preservation is necessary or desirable.

To my mind, the highest value of our wild birds—I speak of birds in general, while I refer especially to those smaller creatures which we describe as song birds—lies not in the useful service they may do to us, although that is not to be underestimated. I am still of the opinion, which I expressed more than a quarter of a century ago, that their æsthetic influence, the effect they exert upon our spirits and in developing our sense of beauty and our appreciation of all that is pleasant and lively in Nature, is of much higher value. We could hardly imagine a landscape of our country, with its alternations of hill and valley, field and wood, pasture and meadow, threaded with streams or dotted with lakes, not enlivened by nimble birds. How bare and empty would our orchards appear, even in the splendor of their spring bloom, without the twitter, the clear songs, the joyous melodies, and the cries of the robins, bobolinks, cat-birds, and blackbirds that haunt them! For any real enjoyment of Nature, we must have the brisk, songful, and noisy bird-life around us. Further than this, we can not doubt that birds, in freedom as well as living with us in our rooms, may be a means of instruction lasting through life, and exercise a profound influence upon youth, by awaking in them an interest in natural life, and leading them to the enjoyment and love of all that is in Nature, particularly in its animal and bird life, and thus eventually to become students of its works and phenomena. In large cities the birds and the flowers are not

rarely all that is left to guard men against being fully estranged from Nature.

But in consideration of the fact that in the materialistic tendencies of our day to turn away from all purely idealistic points of view, and notwithstanding what has been said above, since the main argument for the protection of birds lies in their importance and indispensability for Nature's household and for human welfare, I will also take their actual usefulness into consideration. We dismiss those excessive exaggerations by which each and every bird is represented as necessary. They have done more harm than good to the cause by the sharp and sometimes angry contradictions they have provoked. To designate all birds according to their usefulness or the harm they do would be hopeless; for each bird, even the most useful, may under some circumstances do much harm; so that the useful or injurious character of single species may be exceedingly variable under different local conditions. I may be allowed to adduce a few examples of this.

The sparrow has been of late years one of the most noxious of all birds; and is capable, in fact, in districts under high cultivation, alighting in hosts on fields of ripening grain, or in orchards, of doing great harm. Nobody can, on the other hand, deny that it eats naked caterpillars, worms, and similar vermin; and whoever will can without difficulty satisfy himself that it eagerly catches grub-worms in the spring. The complete extirpation of the sparrow, which is recklessly and improvidently demanded in many quarters to-day, would be a serious wrong and great folly, because it is in many places the single bird destructive to vermin, and the latter would without it increase much faster and become more predominant than hitherto. A similar view may be taken of the bull-finch, whose beauty every one enjoys wherever it shows itself; but it is one of the class which men would banish, for it has in many places developed great power for mischief. It eats the flower-buds from the fruit trees, especially from the pear trees, and thus does great harm. And it is fortunate that in many parts of Germany its young are stolen from the nests by hundreds, domesticated and trained to be singers, and have become an article of trade. Blackbirds and starlings have likewise come to be regarded as obnoxious by narrow-hearted gardeners who look at everything through the spectacles of their own interest. In other respects these birds are among the most useful we have. If we were to estimate the usefulness or objectionableness of all birds, giving heed to the prejudices of every one whose special interest they might in some way damage, we should have to put the ban upon nearly all, and have hardly a species exempt from sentence.

Instead of this, we prefer to apply the measures by which we

may effectively protect our birds in general, so as to preserve them as far as is possible under present conditions.

Against the most important cause of the disappearance of birds, modern agriculture and the removal of the forests, special measures have been adopted with effect in some places, and more are needed. Among these are the plantation of sheltering woods, particularly in or near cities, in public parks, and on all estates, and of thickets in the open fields. These should contain abundant berry-bearing plants and thorny bushes, and might be thickly furnished with nest-boxes, such as are made at several German factories, after patterns indicated by Gloger, in six different numbers. An essential condition to the success of such bird-protectories is the suppression of all enemies of birds and of all disturbers of their nests, egg-collectors large and small. The weakest efforts in behalf of the birds have been those to protect them against unfavorable conditions of weather. Happily, excessive severities of weather, like hard hailstones and terrible thunderstorms, in which birds are numerously sacrificed, are comparatively rare. Lesser weather changes, while they are often not less dangerous to birds, we can more easily contend against. Certainly, any sincere lover of birds, even though he have only a garden or a small yard, or a balcony or a window, can set out food for the support of feathered guests in times of snow or hard frost. But perhaps only a few friends of birds think of the times when the weather conditions are really most unfavorable, and the care of them is most needed. In the late snows and sharp frosts of approaching spring, many of our feathered summer friends are exposed to great hardships, in which they need all the attention that their friends can give them.

The taste for having singing-birds in the house is so widespread and so deeply rooted in popular life that it would be hard to extirpate it. No intelligent man would underestimate its influence on the temper, or its educational, moral, and economical importance, and no well-wisher could desire its complete suppression. And it is demonstrable that bird-catching for the sake of this fancy hardly contributes materially to the diminution in the number of birds. It affects chiefly the males, which among native birds greatly outnumber the females; and when a hunter catches a male of almost any species, another will appear in a short time to fill its place. Egg-collectors, on the other hand, may inflict great damage; and the collector of the present time is not satisfied with one specimen, as formerly, but usually takes the whole laying.

The form of destruction most grievous to thoughtful and sensitive men is that which is pursued for the sake of woman's adornment. It seems hardly possible, at the first look, that an honorable woman, possessed of a delicate, moral, pure, and true

feeling, can find any pleasure in ornamenting herself with a dead bird, whose joyous and harmless life has been cruelly extinguished for her sake. Yet it is a sad fact that thousands of women go around with decorations thus procured, and hundreds of thousands of lovely and useful birds are killed for them. Against this neither words directed to the understanding, lessons on the value of birds, nor warnings appealing to the heart, are of effect; human vanity prevails over all, and triumphant fashion comes off victor. Nothing promises to be effective against it but a positive legal prohibition. Will not our intelligent, warm-hearted women come out with tact and decision against this abuse, and exert their influence upon the wider circle of those who are less judicious but mean well?

Happily, it is among most men only thoughtlessness and consequent indifference, and in only a narrow circle sheer selfishness, that has permitted the neglect or refusal of effective protection to birds.—*Translated for the Popular Science Monthly from Ueber Land und Meer.*

SKETCH OF GEORGE LINCOLN GOODALE.

GEORGE LINCOLN GOODALE was born at Saco, York County, Maine, August 3, 1839. His father, Hon. S. L. Goodale, for about twenty years the Secretary of the Maine Board of Agriculture, is widely known as the author of a standard work on the Breeding of Domestic Animals, and as an agricultural chemist. His mother was a lineal descendant of Rebecca Towne (Nourse), of witchcraft times in Salem.

During his preparation for college, he served as apprentice in an apothecary-store, his grandfather's business, and acquired a good knowledge of the pharmacy of that day. He entered Amherst College in 1856, and graduated in 1860 in the class with Prof. Estey and President Francis A. Walker. After graduation, he remained for a year connected with the college as assistant in chemistry and botany. His teacher in the latter department was the late Prof. Tuckerman. In Tuckerman's Catalogue of the Plants of Amherst and Vicinity the author refers to the excursions made with Mr. Goodale during the years from 1856 to 1861. Among the other teachers then in Amherst College who exerted a marked influence upon the tastes and work of Mr. Goodale should be mentioned the late President Edward Hitchcock and his son Charles, now of Dartmouth, Prof. C. U. Shepard the mineralogist, President Seelye, and the venerable Prof. William S. Tyler.

Being a rapid short-hand writer, he was at one period in his

college course amanuensis to the late President William A. Stearns, with whom to the very last he maintained close relations. In his senior year he began the study of medicine with the well-known and beloved physician Dr. A. Smith, of Amherst, but toward the end of 1861 joined the Portland School for Medical Instruction as a pupil, attending courses of medical lectures in the Medical School of Maine and at Harvard. He received his medical degree at Harvard University in 1863, reading at graduation, a thesis on *Anthrax maligna*. Later in the same year he was given the same degree by Bowdoin College. From this date until 1865 he practiced medicine in Portland, served as City Physician, and gave lectures in the medical school on anatomy, and afterward on surgery and materia medica. During the winter of that year he attended as private pupil, in New York, the special classes of Dr. Frank Hamilton, Austin Flint the elder, and Dr. Shrady; but in February of 1866 his health was so much impaired that he relinquished practice and study, and went by the way of Panama to California. After having executed certain commissions in the inspection of mining property, he visited the principal points of botanical interest in the State, ascending Mount Shasta with a party in August. He made the ascent of the mountain with so little discomfort that he regarded his health as thoroughly re-established. His journey home in autumn was made by the way of Washington Territory, Idaho, Utah, and Colorado, the last part of the long stage-ride being by the "Smoky Hill" route in Kansas the week after the Indian raid of 1866. For a portion of the way the stage party found only smoking ruins of the ranch houses, but no Indians were met with.

In the following year Dr. Goodale visited Europe with his life-long friend, Prof. Brackett, formerly of Bowdoin College, and now of Princeton University. He accepted, in 1868, an instructorship in Bowdoin College and the Medical School of Maine. His connection with those two institutions lasted until 1871, during which period he held the chair of Materia Medica in the Medical School, and of Applied Chemistry and Natural Science in the college.

At the invitation of Prof. Asa Gray, he became assistant in botany in the Summer School of 1871, and later in that year was appointed university lecturer in Harvard. In 1872 he was promoted to the Assistant Professorship of Vegetable Physiology, and in 1877 to the Professorship of Botany. On the death of his teacher, the late Asa Gray, he was appointed to the vacant Fisher Professorship of Natural History.

Many of his vacations have been passed in Europe in the study of economic and physiological botany, the vacation year of 1881–1882 in the laboratory of Pfeffer, in Tübingen, and in Paris.

Harvard professors are expected by the corporation of the

university to perform more or less work indirectly connected with their own departments. That which has fallen to Prof. Goodale's share may be inferred from the following, taken from the last college catalogue: member of the Council of the University Library; member of the Faculty of the University Museum; and, next year, as President of the Boston Society of Natural History, he must act *ex officio* as one of the Trustees of the Peabody Museum. He is also Director of the Botanic Garden of the university.

In addition to the degrees already mentioned, Prof. Goodale has received that of Master of Arts from Bowdoin and from Amherst; from the latter also that of Doctor of Laws.

Among the societies to which he belongs may he mentioned: Phi Beta Kappa, of Amherst; American Society of Naturalists (of which he has been president); American Physiological Society; Society of American Anatomists; the German Botanical Society; the Academies of Philadelphia and of New York; the American Academy of Arts and Sciences; and the National Academy, Washington. He is this year the outgoing President of the American Association for the Advancement of Science.

Prof. Goodale's contributions to science have been chiefly physiological and botanical. In addition to these publications, reference may be made to his work as associate editor of the American Journal of Science, and to his three series of lectures before the Lowell Institute in Boston.

By his activity as a teacher and lecturer he has been successful in exciting a good degree of interest in his department in the city of Boston, and he has been enabled in this way to secure large sums of money for the Botanical Garden, Herbarium, and Museum. By a recent university report it appears that the subscriptions to these objects, within ten years, have reached the sum of one hundred and sixty thousand dollars. With a portion of this money there has been built an extensive addition to the Agassiz Museum, which accommodates amply the magnificent cryptogamic collections and commodious laboratories of Prof. W. G. Farlow, the laboratories of morphological, physiological, and economic botany, and the museums of botany. For the purpose of augmenting the material for the latter, Prof. Goodale has just completed a journey to Ceylon, Australia, Tasmania, New Zealand, Java, Straits Settlements, Cochin-China, China, and Japan. The fruits of this very zigzag tour around the world are beginning to arrive from Victoria and Queensland. Arrangements have been completed by which large collections of objects illustrating the commercial botany of the present day are to be obtained from the principal countries of Europe and the East, and from the southern hemisphere.

But that part of the museum which has absorbed most of Prof. Goodale's thoughts for the last few years is the novel collection of glass models now in process of formation. Every visitor to our large collections in the natural history museums in the great cities has been struck by the marvelous beauty and fidelity of the models by the Messrs. Blaschka, of Germany. The more delicate marine invertebrates, illustrated in glass in this way, appear to be floating in their native element. By successful negotiations with the Blaschkas, Prof. Goodale has been able to secure for the Botanical Museum at Harvard equally beautiful and faithful models of plants and their parts. The results of the artistic feeling of these wonderful artists are simply beyond belief. The plant in flower and bud lies before the spectator as if it had just been taken from the garden or the field. There is not the least suggestion of glass about it. Every minute point has been copied by the artists without the slightest stiffness, and every shade has been given its true value. All the details of structure are given as they would appear under the microscope. In short, the success of the artists has been far beyond what they themselves dared to hope at the outset, and they are now employing all their time in the studies and plastic manipulations by which these creations are produced. By occasional visits to the home of the Blaschkas on the Elbe, and by providing them with a suitable botanical garden at their own door, Dr. Goodale has been able to indicate the range of the work, and to select the American plants to be copied. The enterprise contemplates the use of the exclusive time of the artists for nine years to come, and will involve at least one journey to Mexico and South America by the younger Blaschka. Two ladies of Boston have provided the funds by which this magnificent gift to Harvard University and to botanical science is rendered possible. The collection is to be in memory of the late Dr. Charles E. Ware, of Boston, an enthusiastic lover of natural history. The collection is now accessible to the public, and it will soon be provided with a descriptive catalogue in preparation by Dr. Goodale. The discovery that these remarkable German artists possessed the skill to prepare in permanent glass perfectly faithful copies of flowers and the parts of flowers, and the securing of this skill for his university and for America, may be fairly regarded as an important achievement in a busy life.

Notice is taken by a correspondent of Garden and Forest of a curious peculiarity of the dandelion. Its flower-stalks stand upright till the time of blossoming is past; then bend downward, assume the form of a double curve with the head close to the turf, and in a few days, having greatly increased in length, rise into the air several inches above the height of the original flower, where their ripened, feathery seeds enjoy a free exposure to the winds.

EDITOR'S TABLE.

THE WARFARE OF SCIENCE.

OUR readers have had the opportunity of following, in the interesting articles contributed to this periodical by Dr. Andrew D. White, the marvelous history of the struggle which science from its birth has had to wage with the forces of intellectual obstruction. The great foe to science, it is not too much to say, has been theology. To say this is not to cast doubt on the possibility of a true theology; it is merely to affirm that, in point of fact, the particular theologies that have heretofore occupied the ground have one and all felt themselves threatened by science, and have set themselves to resist its advance by every means in their power. We see no reason why this fact should not be frankly recognized. In the natural course of things theology deals in imaginative fashion with questions of origin and development; and until exact knowledge begins to prevail the notions thus established serve a more or less useful purpose. As knowledge grows, these conceptions are found to be faulty; but theology resists any change—in the first place, from a general conservative instinct, and, in the second, because the cause of moral and social order seems to be more or less involved with the primitive cosmogony. But when once man has begun to observe, to compare, to verify, and to record, he has laid a foundation that can not be shaken, he has sown a ferment that must grow and spread till it has leavened the whole of human thought. Systems founded upon imagination must yield to those produced by the use of the reasoning faculty. They were no better than guesses at the first; and if they furnish an adumbration, however vague, of the truth, it is almost more than we have any right to expect. Reason itself errs in many of its constructions, but it faces the light, and year by year and age by age it is able to perfect its work.

We fail, therefore, to see why any of our religious contemporaries should take in evil part the really instructive treatment which Dr. White has given to this subject of the perfecting of science through opposition and conflict. They really need not feel too bad about it. In a certain way it was good for science, just as it was for the Psalmist, to be afflicted. The natural reluctance which men of science felt to find themselves at variance with established beliefs, armed with the power of persecution, led them to scan their theories very carefully before giving them to the world. Moreover, the very difficulties of the situation drew out much heroism of character, and made science more conscious than it would otherwise have been of its moral and intellectual mission. Whether in these comparatively peaceful times the work of science is done in as high and noble a spirit as formerly is perhaps open to question.

The lesson which nearly all sensible men draw from the history of science is simply this, that the enlightened reason of man is the only interpreter of Nature's laws, and that physical theories handed down from remote antiquity have simply no claim whatever upon our acceptance in the present day. It matters not whether a misapplied ingenuity can find in them some distant resemblance to known facts, any more than it matters, when a weather prophet guesses at the weather, how near the mark or how wide of it his guess may fall. In the present day we have done with guessing in matters scientific. We may frame hypotheses, but, if so, their des-

tination is to be confronted with facts; and if they can not abide the test we let them go. Some of our theological brethren are given to gloating over the mistakes made by scientific men, and point with triumph to the wrecks of scientific theory that lie along the highway of the world's thought. There is little justification for the triumph. No scientific theory ever perished except to give birth to a better. It would be nearly as sensible to take a man to some ancient cemetery and taunt him with the number of his dead ancestors. In humanity is the living germ which persists from age to age, though the generations of men fall like the shed leaves of the oak, and so with science: theories and systems may fail—though not till they have served their purpose—but science as a method, as a principle, as a power survives, and from generation to generation admits us into ever more intimate recesses of Nature's temple. Theology, too, it is sometimes said, is progressive, and, in a certain sense, doubtless it is. But in what does its progress chiefly consist if not in giving up a fruitless contest with science, and recognizing the perfect independence of the latter as an interpreter both of Nature and of man? If theologians are wise they will not only renounce forever the ancient conflict, but they will endeavor to make an ally of science and to impress upon it, to the utmost of their power, a moral aim. The business of science is not to deprive the world of religion, but rather to make religion possible for all men by removing the intellectual difficulties that have in the past more or less hindered its acceptance by enlightened minds. When the voice of authority is no longer raised to stifle intellectual inquiry, science will cease altogether to wear a negative aspect, and will gain universal recognition as the great constructor of whatever is sound in knowledge or of practical value in life; while religion will embrace the emotions and convictions that come to man from the contemplation of the all-comprehending universe and its Transcendent Cause.

INDIVIDUALITY FOR WOMAN.

As a general thing, when the importance of individuality has been insisted on, the individuality in view is that of man. It is he who has been exhorted to assert himself, to be true to his opinions, to live his own life; the exhortation has not been to any great extent addressed to his wife or his sisters. Enough for them if they can be so fortunate as to minister not unworthily to some grand male individuality. Women, however, though not particularly invited to the lecture, have been listening to it, and—what people do not always do with lectures or sermons—are applying it to themselves. The best of them are now aspiring also to be individuals. They want to think, to feel, to know, to do something as of themselves, and, if possible, to think clearly, to feel truly, to know surely, and to do efficiently. St. Paul said that a woman should not be suffered to teach: what would he say if he could attend an annual meeting of our National Educational Association, and see to what an extent woman has become the teacher of the youth of the nation? He said that if a woman wanted any information on doctrinal or religious matters she should go home and ask her husband. The husband of to-day knows more about business than he does of theology; and few wives, indeed, would think of consulting their husbands on the latter subject. In any case the conditions have totally changed since these dicta were uttered. Woman has access now to something wider than domestic teaching. The world of science and literature is open to her, and the need of depending solely upon her male relatives in intellectual matters is not very often felt. Among all the changes that mark our modern time we consider this one of the most important. The elevation of woman means the elevation of man. Many persons have distressed themselves

over the thought of men and women competing for work, and doubtless such competition has already given rise to some unpleasant results. But, strictly speaking, competition *for* work is a feature of an imperfect social system, and therefore, as we may trust, an evil that is destined to disappear; while competition *in* work will remain as a powerful spring of progress. On the other hand, man will be roused by the rise of woman to a competition not so much with her as with himself. If he wishes to win her respect, to say nothing of conquering her love, he will have to be something better on the average than he has been in the past. Heretofore man has, consciously or unconsciously, counted too much on the power of instinct for his influence over woman; while she in turn has regarded him as a creature to be captivated mainly by appeals to the senses and by an appearance of subservience to his wishes. In the future the primitive attraction between man and woman will remain, but it will be so modified by intellectual and moral influences that it will not exercise the same mastery that it has done in the past, nor be so determining an influence in conjugal unions. It is vain to represent to women that it is their *duty* to marry; their first duty is to themselves, and only when marriage can give fuller scope to their individuality will the best women fo the now rising generation care to commit themselves to it. In some ways this may seem to bode evil, seeing that the less advanced will be as ready as ever to marry on the old terms; but, on the whole, we can not doubt that the reflex action on men will carry with it a large surplus of advantage to the world. We want *individual* men—that has long been recognized; but we want also *individual* women—that has only lately been recognized: when once woman becomes an individual in the truest and highest sense, civilization will have reached the threshold of its most glorious period.

LITERARY NOTICES.

GEOLOGICAL SURVEY OF NEW JERSEY. ANNUAL REPORT OF THE STATE GEOLOGIST FOR THE YEAR 1890. By JOHN C. SMOCK. Trenton. Pp. 305, with Map.

MR. SMOCK entered upon the office of State Geologist on the 1st of October, 1890. Previous to that time the clerical work of the office and the superintendence of the distribution of publications had been carried on since the death of Dr. Cook by Irving S. Upson, at New Brunswick. The present report includes work done under Mr. Upson and Mr. Smock. The office of the Survey has been removed to Trenton, but distribution is still attended to by Mr. Upson at New Brunswick. The work of the year includes studies by Mr. Frank L. Nason of the crystalline rocks of the Highlands and of the magnetic ores of that district. An interesting feature of his work is the discovery of fossils in those limestones which give a clew to their age and determine their relative horizon. They have been referred by Prof. Beecher, of Yale, to the Cambrian —below the Potsdam sandstone, the oldest fossiliferous horizon hitherto known in the State. Additional detailed surveys of the country of the crystalline rocks are necessary to an accurate knowledge of the relative position and true nature of the formations grouped as Archæan, and for their correct representation on the geological map. In the southern part of the State preparation has been made, with surveys by Mr. C. W. Coman, for a detailed geological map, showing the limits and areas of the various superficial formations of sands, gravels, clays, peats, tidal marshes, and other recent deposits. The area of the "Trenton gravel" has been ascertained and its limits determined, but its relation to the yellow gravels of south Jersey, and that of the brick-clays to the latter gravel, are yet to be made out. Observations for the volume on water-supply and water-power have been carried on under the immediate direction of Mr. C. C. Vermeule. The census of the water-powers—a new line of inquiry in the history of the survey work—is still in progress, and is, therefore, incomplete. Papers appear in the report on the artesian wells, particularly the recently bored ones in the southwestern coast-belts of the State. A report on the

drainage-work inaugurated by the Survey and successfully carried on, is furnished by Mr. George W. Howell.

GEOLOGICAL OBSERVATIONS ON THE VOLCANIC ISLANDS AND PARTS OF SOUTH AMERICA VISITED DURING THE VOYAGE OF H. M. S. BEAGLE. By CHARLES DARWIN, M. A., F. R. S. Third edition. With Maps and Illustrations. New York: D. Appleton & Co. Pp. 648. Price, $2.50.

GEOLOGICAL changes take place with such extreme slowness that a faithful account of the geology of any place written in Darwin's early life is nearly as accurate now as on the day it was published, and for the purposes of geological history even more valuable. That Darwin's observations are a faithful description of the localities that he visited, no one who knows the extreme thoroughness and conscientiousness of the man will think of questioning. Another fact that has operated to preserve the usefulness of these observations is that they relate to parts of the world that have not been so much studied as Europe and North America, so that the author was able to say in the preface to his second edition, "I am not aware that much could be corrected or added from observations subsequently made." Some of his opinions, however, have not stood the test of time so well as his facts, and were abandoned by Darwin himself in later life. The first half of the volume contains the descriptions of the volcanic islands visited by the Beagle, with a few observations made in Australia, New Zealand, and at the Cape of Good Hope. These islands include St. Jago in the Cape Verd group, Fernando de Noronha, Ascension, St. Helena, and the Galapagos Archipelago. There are several cuts in the text, and a folded map of the island of Ascension is inserted. An appendix comprises descriptions of fossil shells from several of the above-named islands, by G. B. Sowerby, and descriptions of corals from Tasmania, by W. Lonsdale.

The second division of the volume treats of the geology of South America, and almost exclusively of that part of the continent south of the Tropic of Capricorn.

The chapters, except in a few cases, are arranged according to the age of the deposits that they treat of. Considerable space is given to evidences of elevation of the eastern and western coasts of South America, while the formations of the pampas and the structure of the Cordillera are among the subjects of chapters. An appendix contains descriptions of Tertiary shells, by G. B. Sowerby, and of Secondary shells, by Prof. E. Forbes. Several folded plates illustrate the specimens described, and there is a map of southern South America.

THE RELATION OF LABOR TO THE LAW OF TODAY. By DR. LUJO BRENTANO. Translated from the German by Porter Sherman. New York: G. P. Putnam's Sons. Pp. 305. Price, $1.50.

THIS work was prepared by the author in answer to a request from his publishers for a new edition of his "Labor Guilds Past and Present." He thought that something a little different—a popular-scientific treatment of the labor question from the point of view of the labor-guilds—would be of greater interest. It is, according to the translator, "as to quantity of matter an abridgment, as to extent of ground covered, an enlargement" of the original work. The occasion for reproducing the book here is explained by the assumption that the classical political economy of England, prevalent also in this country, has been built up almost exclusively on the side of capital and the capitalist, and is full of theories and assumptions. Writers who have worked upon the structure have been mainly bankers, capitalists, or *doctrinaire* professors. "It is owing to a theory, an exploded theory, the wages-fund theory, that the relations of labor have not been scientifically discussed by our economists, and the treatment of the labor question has been left mainly to unscientific, more or less socialistic, even revolutionary, writers." As taught thus it discloses an antagonism between theory and practice, and is charged with furnishing ammunition to socialism. "Recognizing this antagonism, the political economists of Germany have set themselves to work to correct and to supplement, in this and other particulars, the classical, hypothetical, abstract political economy." Further than this, by a critical examination of the principles furnished by the English economists, upon which the socialists have built their superstructure, "the German economists have been able to modify, correct, and supplement them, and have

thus undermined the theoretical foundations of socialism." Prof. Brentano has had exceptional facilities for the study of English trades-unions, having spent several years in the country, with free access to their records and archives; and he is master of the English language, and on familiar terms socially with English manufacturers and laborers. He also occupies (at Leipsic) one of the highest chairs of Political Economy in Europe. At the beginning of the present treatise he lays down, as the three principles which have in turn sought to govern the economic life of the ages, and struggled with each other for the mastery, those of authority, individualism, and socialism. Although each of these principles claims absolute correctness and exclusive control, no one of them has ever governed exclusively, nor has any one of them been entirely without effect. It is the task of science and of this book to investigate the relations, force, and operation of these principles in life. The conclusion of the whole is that the necessary key-note of our age, as of every epoch of grand progress, is individualism; but there are minors who need the protecting interference of the state, and for them the control of authority is still a necessity; but it must not be stretched beyond what is necessary. It must not be extended to those weak ones who, not isolated, but united, are able to guard their own interests. The fundamental principle of the economic order remains the free self-activity of individuals for themselves, and the free road necessary to the talented and the strong for the full development of their powers lies open to all. But the weak united arrive by it to independence, the minors acquire through it the necessary protection by means of legal barriers against abuses of economic superior power. "Wherefore this regulation of the labor relation contradicts the efforts of the feudal socialists who speak of the return of the old control of authority, in order by preventing the independence of the members of the lower classes the better to guard their own special interests. Wherefore, it contradicts further the demand of the social democrats to set aside all individual and social inequalities. But it corresponds with the ideals which have produced the great transformation of the entire social and political life since the end of the eighteenth century," and with the moral and political ideals of the age and with the fundamental principles of the law of to-day.

ACHIEVEMENTS IN ENGINEERING. By L. F. VERNON-HARCOURT. New York: Charles Scribner's Sons. Pp. 311, with Plates. Price, $1.75.

THE author's purpose in this book has been to describe briefly some of the principal engineering works carried on during the last fifty years, in a style as free as possible from technical phraseology and intelligible to the general reader, at the same time introducing details and comparisons that will be interesting to engineers as well. A superabundance rather than a deficiency of material has been met, for the chief engineering triumphs have been accomplished during the last half-century, and the variety of adaptation has been almost endless. The author believes however, that an adequate variety of engineering works of great magnitude, difficulty, and importance have been described to justify the view that engineers, in directing the forces of Nature to the use and convenience of man, are among the greatest benefactors of mankind. American works are well represented, with descriptions of the New York elevated railways, railways across the Rocky Mountains and the Andes, the Detroit, Hudson, and Sarnia Tunnels, the St. Louis and Brooklyn Bridges, the operations at Hell Gate, the improvement works on the Mississippi, and the Panama and Nicaragua Canals, and many other American works are mentioned in illustration of principles. The list of works abroad described or referred to would be cumbrous to quote. In it all the classes we have mentioned are represented with the grandest achievements of foreign engineering. All together, however, are only a few remarkable instances chosen out of a great number of important works which engineers have carried on in almost every part of the world. It is impossible, the author adds, within a limited space, "to refer to various other branches of engineering science in which the skill of the engineer has conferred inestimable benefits on the human race. It has been shown how all the works facilitating locomotion on land, and affording access from the sea to ports, and by water-ways to the interior of a country, are due to the labors of engineers, and how the indispen-

sable water-supplies for large towns are secured by their aid. Engineers, however, also provide for the drainage of large towns and districts, the mitigation of inundations on low-lying lands, the reclamation of lands from the sea, and the irrigation of large tracts of land in warm countries by which crops are preserved and famine averted, and they carry out the works for the illumination of streets and houses with gas and electricity. To their credit also are improvements in marine engines and increased speed of ocean steamers, and improvements in telegraphy and the laying of submarine cables, and if engineers in the future continue as in the last half-century, increasing and extending the benefits resulting from their works, they will justly be regarded as ranking among the greatest benefactors of mankind."

THE OYSTER: A POPULAR SUMMARY OF A SCIENTIFIC STUDY. By WILLIAM K. BROOKS. Baltimore: the Johns Hopkins Press. Pp. 230, with Plates. Price, $1.

PROF. BROOKS is our most thorough and successful student of the oyster. He has devoted a large part of his time to the study for more than ten years past, and, as President Gilman says in the introduction to this book, "he can hold his own not only among naturalists, but also among practical men. He has dredged in every part of the [Chesapeake] bay. To use his own words, he has tonged oysters in five different States; in the warm waters of the South he has spent months under the broiling sun, wading over the sharp shells which cut his feet like knives, studying the oysters 'at home.' He has planted them, he has reared them by collecting the floating spat, and he has hatched from artificially fertilized eggs more oysters than there are inhabitants of the United States." He has also studied the experience of other States and countries, and has gathered up the knowledge of the world in respect to the life of the oyster, "its enemies and its needs, its dangers and its protections." The results of this practical work and these studies are embodied in the present book in familiar style and language for the information of the public. The whole work—studies and book—has been prompted by the fact, which is printed in capital letters, that "the demand for Chesapeake oysters has outgrown the natural supply." Prof. Brooks's effort has been to find a way to increase and supplement that supply. For this, his essay offers many suggestions of value.

POPULAR LECTURES AND ADDRESSES. By Sir WILLIAM THOMSON. Vol. III. Navigational Affairs. London and New York: Macmillan & Co. Pp. 503. Price, $2.

VOLUME third of this series of addresses precedes volume second in publication because considerable matter had been prepared on navigational subjects which were assigned to the third volume in the plan of the series, before any progress had been made with the geological lectures. The lectures included in this volume are one on Navigation, delivered to the Science Lecture Association; a British Association evening lecture on The Tides, with parts of a lecture before the Glasgow Association on the same subject; a British Association paper on the Influence of the Straits of Dover on the Tides of the British Channel and the North Sea, with appendixes on the tides of the southern hemisphere and the Mediterranean, and a sketch of a proposed plan of procedure in tidal observation and analysis, and on the equilibrium theory of the tides; and papers on Terrestrial Magnetism and the Mariner's Compass; Deep-sea Sounding by Pianoforte Wire; Lighthouse Characteristics; the forces concerned in the laying and lifting of deep-sea cables; and Ship Waves. To these is appended a concluding paper by Captain Creak, R. N., on the disturbance of ships' compasses by the proximity of magnetic rocks at considerable depth under water.

NATURAL SELECTION AND TROPICAL NATURE. By ALFRED RUSSEL WALLACE. New edition, with Corrections and Additions. London and New York: Macmillan & Co. Pp. 492. Price, $1.75.

MANY persons who have been interested by Mr. Wallace's Darwinism, and are not acquainted with his early works, will doubtless welcome this reprint of two volumes of his biological essays. These papers are popular enough to interest the general reader, while containing able discussions of impor-

tant scientific problems. In preparing this edition two especially technical essays have been omitted, another has been divided and the parts relocated, and many corrections and some important additions have been made in various places. Two new papers have been added to the Tropical Nature and other Essays, namely, The Antiquity of Man in North America, and The Debt of Science to Darwinism. This division of the volume comprises also chapters on the animal life, vegetation, climate, and other features of the equatorial zone, tropical humming-birds, the colors of animals and sexual selection, the colors of plants and the color-sense, and the antiquity of man. Among the subjects of the essays on Natural Selection are the introduction of new species, protective resemblances, instinct, the philosophy of birds' nests, and natural selection applied to man.

THE ELECTRO-PLATERS' HANDBOOK. By G. E. BONNEY. Illustrated. New York: D. Van Nostrand Co. Pp. 208. Price, $1.20.

THE amateur who would like to possess table-ware, jewelry, or miscellaneous articles plated with silver or gold by his own hands, and the intelligent boy in a plater's shop who wants to supplement his oral instruction with a record of facts and figures that he can not well carry in his memory, will both find their needs supplied by this manual. Much or little electrical and mechanical knowledge may be used in electro-plating: the amateur may make his own battery or dynamo if he desires, or he may buy apparatus of one of the kinds and makes named in this book. The author tells just what kinds are suitable for doing plating, and why, and also describes the vessels, brushes, lathes, etc., required for the work. He next gives a chapter on preparing the work, which includes thorough cleaning and the grinding out of all scratches, pits, and roughness. The latter operation may be done very laboriously by hand, but the amateur will have it done in some shop on a lathe. The operation of "stripping" the remains of the old coating from articles that have been plated before, and the use of "dipping" and "quicking" solutions are also described here. Separate chapters are then devoted to electro-plating with silver, gold, nickel, copper, alloys, and with zinc, tin, iron, etc. All the little points that need attention are touched upon in each case, and in the chapter on silver full directions are given for burnishing the work. The directions are everywhere simple and concise, and the book is not burdened with historical matter, various alternative processes, or elementary science. The volume is amply illustrated, has a portrait of Faraday for a frontispiece, and has an index.

AN INTRODUCTION TO THE STUDY OF MAMMALS, LIVING AND EXTINCT. By WILLIAM HENRY FLOWER, F. R. S., etc., and RICHARD LYDEKKER, F. Z. S., etc. New York: Macmillan & Co. Pp. 763. Price, $6.

THIS work is based largely upon the article Mammalia, together with forty shorter articles, written by the senior of the two authors for the ninth edition of the Encyclopædia Britannica. The article Ape, by Dr. St. G. Mivart, and several articles by Dr. G. E. Dobson and Mr. Oldfield Thomas, have also been used, with the permission of the writers. This material has been arranged, the gaps between the several parts have been filled, and new matter, especially on the extinct forms and the group *Artiodactyla*, has been added. Anatomy and classification are the subjects most largely treated, comparatively little attention being given to habits and mental traits. The text is illustrated with three hundred and fifty-seven figures, most of which appear in the Encyclopædia articles above mentioned, while some have been drawn for the present volume, and some obtained from other sources. The well-known character of the Britannica is a sufficient index of the high quality of this work.

A DICTIONARY OF APPLIED CHEMISTRY. By T. E. THORPE, F. R. S., assisted by Eminent Contributors. Vol. II. London and New York: Longmans, Green & Co. Price, $15.

THE second volume of this important work goes from *Eau de Cologne* to *Nux Vomica*. Its most extended articles are those on Explosives, Fermentation, Gas (Coal, Oil, and Water), Glass, and Glycerin, on the metals Iron, Lead, and Mercury, and on India Rubber, Iodine, Matches, and Milk. The metallurgical articles treat extraction processes with considerable detail, and give

many figures of the apparatus employed. Such manufactured products as glass, matches, and gas are treated with similar fullness. An example of the important articles that do not deal with technology is the one on Fermentation. In this article the difference between the organized and the unorganized ferments is first set forth. The organized ferments are then treated in the three groups, molds, saccharomycetes, and schizomycetes, and the ordinary methods of cultivation and study are briefly described. Next the various fermentations caused by each of these three groups are discussed, those induced by bacterial life being arranged in four subgroups, viz., fermentation by hydration, by decomposition, by reduction, and by oxidation. Putrefaction is also considered in this article, and the closing section deals with soluble ferments. The writer is Prof. Percy F. Frankland. Among the contributors of other important articles are Prof. P. P. Bedson (Lead), the late W. Lant Carpenter (Glycerin), W. H. Deering, of Woolwich (Explosives), J. J. Hammel (Fustic, Indigo, Lakes, Litmus, Madder, etc.), R. Warington (Artificial Manure, Nitrification), and Prof. W. P. Wynne (Ketones, Naphthalene). Among the chief articles which are unsigned and hence presumably by the editor are Ethyl Compounds, Fatty Acids, Fluorine, Lactic Acid, Manganese, Mercury, Milk, Milk-sugar, and Nitrogen. The names of its editor and contributors are a sufficient assurance that this dictionary will take high rank as a work of reference.

A HISTORY OF CHEMISTRY. By ERNST VON MEYER, Ph. D. London and New York: Macmillan & Co. Pp. 556. Price, $4.50.

A LARGE task has been thoroughly performed in this work. The history begins in the earliest times—before the birth of alchemy—and records the acquaintance of the Egyptians with metallurgy and with other technological chemical processes, and the theorizing of the Greek philosophers in regard to the elements of substances. It then traces the progress of alchemy from its earliest known manifestations in Egypt down to the eighteenth century. A chronicle of the iatro-chemical period follows, in which Paracelsus, Van Helmont, and De le Boë Sylvius were the leading spirits. The next chapter deals with the period of the phlogiston theory, from Boyle to Lavoisier, and the last division of the subject extends from the time of Lavoisier up to now. The knowledge of technological processes current in each period is set forth in these several chapters, and in the closing chapter the special history of each of the chief divisions of chemistry in the past hundred years is given. The plan of the work involves a statement of the attitude of each prominent chemist toward the science of his time and its problems, and an estimate of the effect and value of his work. This criticism has been continued even down to the investigators of recent years. A controlling purpose of the book is to describe the development of the general doctrines of chemistry from their earliest beginnings up to the present day, and thus to give a comprehensive survey of what is one of the most interesting panoramas in the history of science. The following extract illustrates the nature of the book:

Dumas did not scruple to say plainly that the dualistic doctrine was harmful and retarded the development of organic chemistry, and he made every effort to set it aside and to replace it by the unitary theory. His attack upon Berzelius's doctrine (at that time held in high repute by most chemists) was vigorously answered both by the latter and by Liebig. Liebig indeed admitted many points which were disputed by Berzelius—e. g., the fact of substitution—but he protested against Dumas's wide extension of this principle (of substitution). The assertion of the latter that every element of a compound might be replaced by another, and yet the type be retained, was characterized by Liebig as entirely unproved, and met with an ironical rejoinder. Berzelius, who saw his whole system based upon the electro-chemical theory threatened, directed his criticism in the Jahresberichten for 1838 and the next five years or so against the theory of types.

MISSOURI BOTANICAL GARDEN. SECOND ANNUAL REPORT. By WILLIAM TRELEASE. St. Louis: Published by the Board of Trustees. Pp. 117, with Plates and Plans.

THE first volume of the reports of this institution, published in December, 1890, having been primarily intended to give an account of the establishment of the Garden and School of Botany, the present volume really begins the series of annual reports. The estate, including Shaw's Garden, is valued at $1,366,334. Much labor and money have been spent in putting the premises in

repair. Efforts have been made to improve the garden in all respects, but particularly in those features which will make it attractive and instructive to visitors, and render possible in it the performance of substantial and useful botanical work. The task of mounting the Engelmann herbarium has been nearly completed, and the collection is temporarily deposited in a nearly fire-proof building, awaiting the erection of a permanent fire-proof house. Measures will then be taken to form a museum. The record is given of the school of horticulture, in which provision is made for six pupils at once, and the announcement of the Washington University School of Botany, to which the garden furnishes a laboratory and working-ground. Besides these accounts of routine work, the volume gives the proceedings at the first annual banquet to gardeners, florists, and nurserymen, given December 13, 1890, and, under the heading of "Scientific Papers," a revision of the American species of *Epilobium* occurring north of Mexico, by Mr. Trelease, which is richly illustrated.

THE SOUL OF MAN. AN INVESTIGATION OF THE FACTS OF PHYSIOLOGICAL AND EXPERIMENTAL PSYCHOLOGY. By Dr. PAUL CARUS. Chicago: Open Court Publishing Co., 1890. Pp. 458. Price, $3.

THIS work, containing one hundred and fifty-two illustrations and diagrams, chiefly of the nervous system in man and the lower animals, aims to present some account of The Philosophical Problem of Mind, The Rise of Organized Life, the basic facts of Brain Activity, some remarks upon The Immortality of the Race and the Data of Propagation, the results of some of The Investigations of Experimental Psychology, and The Ethical and Religious Aspects of Soul-life. According to Dr. Carus, the true conception of the soul is as form. The idea of form, he thinks, is not a mere speculative theory, but of practical importance, especially as related to the problem of life after death. The following passage will indicate the author's position on this point: "Man's soul was formed in the course of the evolution of the human race by the reactions upon the external influences of the surrounding world, and the present man is the outcome of the entire activity of his ancestors. . . . Every one of us began his life with the beginning of all life upon earth. We are the generation in which the huge billow of human life now culminates. We, ourselves, are that billow; our real self, our spiritual existence, will continue to progress in that great wave.

"Our existence after death will not merely be a dissolution into the All where all individual features of our spiritual existence are destroyed. Our existence after death will be a continuance of our individual spirituality, a continuance of our thoughts and ideals. As sure as the law of cause and effect is true, so sure is the continuance of soul-life even after the death of the individual, according to the law of the preservation of form" (p. 423).

The author regards "as not the least important feature of the book" its philosophical foundation as corroborating "the unitary conception of the world, commonly called Monism, or, more exactly expressed, Monistic Positivism."

A Clinical Study of Diseases of the Kidneys has been published by *Clifford Mitchell*, M. D. (Keener), in which the author insists on the importance of thorough examination of the urine for information in regard to not only diseases of the kidneys but also many other disorders, and in regard to the effects of diet and treatment. One hundred pages are devoted to the treatment of Bright's disease, including the regulation of diet, air, exercise, care of the skin, place of residence, psychical influences, etc. In writing this book the author has kept in view the needs of American patients, and has shunned those recommendations of English writers on diet and hygiene which are not suited to the climate of America. Although the title of the book limits it to renal diseases, the author has deemed it necessary, in connection with these, to pay attention also to those of the entire urinary tract.

Examen Quimico y Bacteriológico de las Aguas Potables is a treatise on drinking-water and its impurities by A. E. Salazar and C. Newman, of the laboratory of the Naval School at Valparaiso, Chili. It is the result of studies of the waters of the city carried on in the laboratory in 1887 and 1888, and is published partly as a guide to those who wish to make similar studies in other parts of the

republic. Besides their own experiments, the authors, to qualify themselves for their work, visited the principal laboratories of Europe, including those of Dr. Miquel, of Montsouris; Dr. Ferran, of Barcelona; Prof. Emmerich, of Munich; Dr. Korralsky, of Vienna; Prof. Fodor, of Buda-Pest; and Dr. Fraenkel, of Berlin. The first part of the treatise relates to the examination for mineral constituents, including the determination of the weight of solids, of alkalinity, noxious metals, chlorine, nitric and nitrous acids, and gases; the second part, to the examination for organic impurities by the ammonia and permanganate processes; and the third part, to the bacteriological examination. To this is added a chapter on parasitical animals introduced by water into the organism, by Dr. Rafael Blanchard, of Paris. The work is illustrated by one hundred and twenty-seven engravings, sixteen photomicrographs, and five photograms of cultivations, and is published in London in Spanish by Burns & Oates.

Persifor Frazer's useful *Tables for the Determination of Minerals by Physical Properties ascertainable with the Aid of a Few Field Instruments* is published by the J. B. Lippincott Company in a third edition, entirely rewritten. The author's first intention was to introduce the method of determination pursued in the Royal Saxon Mining Academy at Freiberg, in a translation of Prof. Weisbach's tables; but he soon found that it would have to be modified in many particulars in order to meet the wants of American readers; and the changes and additions were so numerous as to make virtually a new book. The principle is insisted upon that every true mineral is a definite chemical compound or element, homogeneous throughout its parts, and capable of expression in a chemical molecular formula. This principle, which was at first opposed by Prof. Dana, has now been tacitly conceded by all modern writers, including Prof. Dana himself. The minerals are classified for purposes of identification into those of metallic luster, and then, subordinately, according to their colors; those of submetallic and non-metalic luster, and the color of their streak; and minerals of non-metallic luster with white or light gray streak, and according to their sectility or hardness. $2.

In *A Preliminary Report on the Geology of the Central Mineral Region of Texas*, which forms a part of the first Annual Report of the Geological Survey of the State, Mr. *Theodore B. Comstock* assumes that the region has never been adequately studied, and criticises the references to it by the geological writers who have spoken of it as betraying want of information. In his own report he gives only definite results which the facts known are fully believed to warrant. Of statements of previous authors which he summarizes a certain number have been verified by his observations, while as many more have been found incorrect; and, as a result of the field work of 1889, a considerable amount of new and wholly unexpected structure has been worked out.

Mr. *Ernest E. Thompson*, in his monograph on *The Birds of Manitoba* (United States National Museum), has made the political boundaries of the province the boundaries also of the district included, although it does not constitute a distinct zoölogical province. He spent altogether about three years in the province and in his studies of birds. He offers his observations as they were made on the spot, without condensation or generalization, believing that the only right course under the circumstances. His original plan was to prepare something "after a very old-fashioned model," but widening experience caused a change of view. His own observations are supplemented by those of numerous observers in different parts of the province, and citations of other scattered published matter. From his sketch of the physical features of the province, we learn that it is plentifully, almost too plentifully, supplied with water. Besides the numerous extensive lakes indicated on the map there are thousands more of smaller extent, while the region of the Red River Valley in particular is diversified by vast stretches of marsh and lagoon. The lakes consist of sweet or live-water lakes of various sizes, fed and drained by living streams and teeming with fish; and the alkaline lakes, which are mere drainage basins, and depend on evaporation for the removal of their accumulated waters. They owe their alkaline constituents to the continual influx and evaporation of surface water slightly impregnated with alkali, through running over the prairies

strewn with the ashes of the annual fires. These "dead lakes" do not contain fish, but swarm with a species of *Amblystoma*, and leeches and aquatic insects, and are frequented by certain kinds of birds that seem to avoid the fresher waters.

In a paper on *Revised Astronomy* a contribution is made to theoretical astronomy from a new base by the Rev. *James W. Hanna*. After twenty years of study he has come to the conclusion that all the attractive forces of organic nature are one; that connected with it is another force, equally general and important, of repulsion; and that the resisting medium of space plays a larger part in the economy of the universe than it has been accredited with. Keeping these principles in view, he finds much in received astronomical theories to be corrected, and formulates his views in thirty-eight propositions. (Fleming H. Revell Co., Chicago and New York. Price, 35 cents.)

In an address on *The New School of Criminal Anthropology* delivered before the Anthropological Society of Washington by Dr. *Robert Fletcher*, the principal results of the labors of Prof. C. Lombroso, of Turin, are briefly presented, together with references to the works of other writers who are disposed to regard criminals as constituting to a greater or less extent a distinct class of the human race.

In the *Annual Report of the Chief Signal Officer of the Army for 1890* a decided improvement is noted in military signaling. During the year the heliograph was largely used in Arizona, nearly two thousand miles of military and sea-coast telegraph lines were operated, and considerable use was made of telephones. The meteorological work included the issuing of weather and temperature forecasts, the display of storm-signals, the gauging and reporting of rivers for navigation and flood-warnings, and the publication of weather maps, hurricane reports, the Weather Crop Bulletin, and the Monthly Weather Review. The percentages of successful forecasts were 84·4 for weather and 78·7 for temperature, giving a general average of 82·6. This is excellent in view of the statement made that "the average time at the disposal of the forecast official for the discussion and formal issue of weather forecasts is forty-nine minutes in the morning and fifteen minutes more at night," and that consequently "rarely can a minute be given to the predictions for any particular State or district." The accuracy of weather and temperature predictions had increased 1·7 per cent over the previous year; that of storm-signals had remained practically the same, 67·1 per cent. The details and statistics of the above and other work of the Signal Corps are given, with many maps, in special reports that occupy the greater part of the volume.

A *Report on the Cahaba Coal-field*, by *Joseph Squire*, has been issued by the Geological Survey of Alabama. This report describes the geology of the region, the chemical composition of the coals from different parts of the field, and the methods of mining employed there. Appended to the report is an account of the Geology of the Valley Regions adjacent to the Cahaba Field, by Eugene A. Smith, the State Geologist. The volume is illustrated, and is accompanied by a folded map.

Mr. *Arthur Winslow*, State Geologist of Missouri, reviewing, in his *Biennial Report of the Bureau of Geology and Mines*, the history of the geological survey of the State in past years, finds that "its life has been very fitful. It has existed for a few years, only to be discontinued before any plan of work was completed and at the sacrifice of much of the result reached. It has been weakened by successive changes of management with accompanying changes of policy. Its trained corps of employés and its equipment for work have been lost during the interim between two periods of activity; its collections, designed to illustrate the resources of the State, have been scattered, and with it all a considerable sum of money has been expended." The present management has spent a year in preparation, and is entering upon a systematic work. It is to be hoped that it will be left alone long enough to accomplish something of permanent value.

Parents who have never taken much thought as to what kind of schools their children go to should read *The Coming School*, by *Ellen E. Kenyon* (Cassell, 50 cents and $1). It is a companion to The Young Idea, by Miss Le Row, which reveals the sad absurdities that characterize the prevalent

machine education, and supplements that book by pointing out the features that should be secured in the school of the future. The author's suggestions are illustrated by accounts of lessons actually given in some exceptionally fortunate schools of the present day. Among the chief changes urged by Miss Kenyon are that political boards of education shall give way to professional boards; that minute regulation shall be banished from the schools; and that the best teachers shall be assigned to the work of primary teaching, which is the foundation underlying all higher education.

The twenty-first "Summer Number" of *The School Journal* (New York) gives evidence of vigorous life in that publication. Its contents includes articles on a wide range of educational subjects, and the number is illustrated with portraits of prominent educators, plans of school buildings, and diagrams for drawing, writing, and other lessons.

The series of *Picturesque Geographical Readers* (Lee & Shepard, Boston) has been projected by Mr. *Charles F. King*, to make the learning of geography a source of pleasure as well as of real instruction. It aims to present the important facts of the science in a simple, interesting narrative style, so as to make the relation attractive. The books are intended to be used with the regular geography or atlas, and not in place of them; with the large and fuller maps of the text-books opened upon the pupils' desks, and the wall maps hung up, to be freely consulted as the lessons are read. It is advised also that the pupils be encouraged to write stories in connection with the pictures found in the book, to give oral abstracts of the lessons read, to name the pictures seen, to write the best single word to suggest the story in the chapter, and to draw and make as many of the illustrations as they can. The present volume is the second book of the series, and relates to this continent of ours. In it are given, in dialogue form, descriptions of the principal physical features of North America, including the frozen region, whaling, the land and water masses, the mountains, the Yellowstone Park and its geysers, central plain and eastern highlands, the rivers, climate and lakes, with special chapters on a few minor features; then an account on a similar plan of the Dominion of Canada; whence the reader is jumped, passing a special description of the United States, to like descriptions of Mexico and the West Indies.

A paper on the *Evolution of the Ordinance of 1787, with an Account of the Earlier Plans for the Government of the Northwest Territory* (G. P. Putnam's Sons), by *Jay A. Barrett*, is the first of a new academic series of papers, to be called the Seminary Series, which is started in connection with the Departments of History and Economics of the University of Nebraska. The institution of these series, in which historical, political, and economical questions are discussed in carefully studied monographs, is regarded in an editorial note as a sign that American universities are at last becoming centers of organized literary work. It affords a means also by which students may do useful work, make considerable additions to knowledge, and do the State a service. In the belief that a division of the labor is expedient, the Seminary Series, while not excluding other topics, will deal mainly with questions relating to Western history and economics. The *Evolution of the Ordinance of 1787* is a good beginning.

In a book on the *Origin, Purpose, and Destiny of Man*, of which Mr. *William Thornton*, of Boston, is the author and publisher, the doctrine is unfolded that all things are made up of three states, which are called the three ethers. Life is the first ether, which is a continuous aggregate. The second ether is a composition of the potentialities heat, light, electricity, and magnetism, mechanical power being manifested during the activity of these potentialities. The third ether is a material nucleus which permits of the action of the other two ethers. All bodies manifesting the second and third ethers independently of the first make up inorganic bodies. Organized bodies require all these ethers. These two conditions constitute all things natural and supernatural. The Creator is not to be found in the universe in any morphological form, but has only a subjective existence; and it is only when the subjective part of man exists as a distinct entity that he can ever know God.

Two novels of considerable merit, and

displaying much skill in construction and development, claim our attention. *What's bred in the Bone* (Benjamin R. Tucker, publisher, Boston) is a story of certain aspects of English social life by an author well known to our readers, *Grant Allen*. The story is told in a terse, vigorous style, without padding by expansion or episodes; the intricacies and complexities of the plot are tangled and untangled as by the hand of a master at the business; and an intense interest is wrought out. The name of the story seems to relate to a singular power of fascination which the heroine inherits from a gypsy ancestor, and to the persistency with which the gentle birth of the hero and his brother, made by circumstances friendless waifs on the surface of society, is declared in their acts and manners.

In *Juggernaut* (Fords, Howard & Hulbert) a chapter of American life and experience is handled with great power and truth to the reality by *George Cary Eggleston* and *Dolores Marbourg*. The Juggernaut is the idol ambition, or the car worldly success, under which an American starting as a young man with pure and noble intentions, and the purpose to maintain his character, is cast, with his wife, who has had simple and as pure beginnings, to be crushed. The story is one of the ruin of character that is so common in our financial and political life. The young editor, who has been honest and free, and is determined to continue so, is unwittingly drawn into the power of a schemer on whom he is for the time dependent, and is compelled to prostitute his paper for the furtherance of a single design of the other. He is determined to get the better of his master, and does it; becoming in his turn a speculator, financial operator, senator, and political schemer; making his wife, who was designed for the best things, his lobbyist, till she revolts at her fate, and ruin overtakes the pair. The story furnishes an instructive illustration of the fatal tendency of what are two conspicuous features of our national life.

A third story, by *J. Van Lennep*, translated from the French by Mrs. Clara Bell, *The Story of an Abduction in the Seventeenth Century*, is based on history. The foundation narrative is related in the fifth volume of Aitzema's Affairs of State and War, and concerns the carrying away from her friends by Johan Diederick de Mortaigne of a Dutch young lady, Catharine d'Orleans, and the pursuit of them, with divers political and diplomatic complications which the event evolved.

Our Language is the name of a modest journal of eight pages, devoted to preserving and improving the English speech, which is edited and published monthly by Mr. *Frederik A. Fernald* in this city (1778 Topping Street, fifty cents a year). The editor is an experienced journalist of literary taste and acquirements, and is an earnest advocate of a rational reform in spelling. That subject, the derivation and right use of words, and proper constructions are the chief topics discussed in its pages, and the spirit of the discussions is candid and catholic. Eccentric notions are not tolerated; and, while *Our Language* favors further reforms in spelling, it practically uses those changes only which have been agreed upon by all the reformers. The editor is in personal communication with the leaders in the reform movement, and enjoys their co-operation in his enterprise.

Science of Every-day Life and *Science applied to Work* (Cassell) are two convenient and useful treatises prepared by *John A. Bower*, the former for the Young People's and the other for the Artisan section of the National Home Reading Union. The chapters in Science of Every-day Life treat of some of the most common things, and the reasons for their existence: matter, weight, motion, air, combustion, and water; and furnish a few simple, rudimentary experiments. Science applied to Work is intended to be a useful introduction to the Science of Practical Mechanics, free from mathematical formulas, and to furnish hints for making mechanical experiments with simple contrivances. Both works aim to be clear and accurate in all their statements.

Having been, as an analytical and consulting chemist, frequently called upon to give information on the subject of water in its relations to disease, and having had much to do with the subject in connection with the Iowa State Board of Health, Dr. *Floyd Davis* has been happily prompted to prepare *An Elementary Handbook on Potable Water*, which is published by Silver, Burdett & Co.

In it are discussed the impurities in drinking-water that are oftenest the cause of disease and death, and the natural and artificial processes of removing them. The author's conclusions are the fruit of an experience gained in the analysis and study of nearly a thousand water-supplies, and are aided and re-enforced by the studies and writings of others. A definition of pure water, in a potable rather than a chemical sense, is sought in the first chapter. The inorganic, the vegetable, and the animal constituents of water, micro-organisms, water-supplies, natural and artificial purification, and central filtration, are considered in the several succeeding chapters. Of analysis, only a few elementary qualitative tests are mentioned, the general subject being reserved for another book, which is announced. The language is such as can be easily understood by every intelligent person.

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POPULAR MISCELLANY.

Exploration of Mount St. Elias.—The Mount St. Elias expedition organized by the National Geographic Society, under the leadership of Mr. I. C. Russell, with Mr. Mark B. Kerr as topographer, left Seattle, Washington, in June, 1890, and after spending more than two months on the mountain-sides, one half of that time above the snow-line, returned with notes, specimens, and data of the greatest interest. The topography was sketched over an area of about one thousand square miles, and includes the determination of the geographical position and elevation of Mount St. Elias and many neighboring peaks. Mount St. Elias is indicated to be not so high by some four thousand feet as the heretofore accepted elevation, nineteen thousand five hundred feet. The difficulties attending the determination of the height of this mountain are so great that the range between the extreme elevations that have been given by different explorers is nearly six thousand feet. Vice-President Ogden, of the National Geographic Society, suggests that as this is believed to be the first height for the mountain that has been derived from a carefully measured base, it is entitled to much weight. But the difficulties in suitably placing the triangles of measurement were so great that even the new elevation must be accepted with caution till it is verified. Although the party were prevented by storms from reaching the summit of Mount St. Elias, Mr. Russell is confident that he has found a practicable route.

A Glacial Monument.—One of the most interesting objects of the excursions of the Cleveland meeting of the American Association of 1888 was the group of wonderful glacial grooves on the limestone of Kelley's Island, Lake Erie—probably the most remarkable specimen of the kind in the world. The rock was being rapidly quarried away, and the pleasure felt at the sight of so rare a specimen of glacial action was marred by the apprehension that it would soon all disappear, a sacrifice to the commercial spirit of the age. A pledge was given at the time by the President of the Kelley's Island Lime and Transport Company, owning the quarry, that the most interesting grooves should be preserved. This pledge has now been fulfilled. The company at its last annual meeting voted to deed to President M. C. Youngblood a strip of land fifty feet wide and a hundred feet long, as surveyed by Prof. G. F. Wright and the Rev. Dr. Sprecher, containing the groove, to be deeded by him to some scientific or historical society, to be preserved in perpetuity for the benefit of science. It is to be presented to the Western Reserve Historical Society of Cleveland. The portion of the groove preserved is thirty-three feet across, and is cut in the rock to the depth of seventeen feet below the line extending from rim to rim. The groove is not simple, but presents a series of corrugations merging into one another by beautiful curves. When exposed for a considerable length, it will resemble nothing else so much as a collection of prostrate Corinthian columns lying side by side on a concave surface. Quarrying has proceeded nearly all around the specimen, "and soon the monument preserved will be a monument indeed," the groove being left to cap a pedestal about thirty feet high, and conspicuous from every side. About one half of the surface will be cleared of *débris*, so as to show fifty feet of the length of the groove, while the other half will remain as it is, beneath the protective covering of gravel, sand, and mud.

Characteristics of Aboriginal American Poetry.—The characteristic feature of the aboriginal poetry of America is defined by Prof. Brinton, in his presidential address to the Numismatic and Antiquarian Society of Philadelphia, as repetition. "The same verse may be repeated over and over again; or the wording of the verses may be changed, but each may be accompanied by a burden of refrain which is repeated by the singer or the chorus. These are the two fundamental characteristics of aboriginal poetry, which are found everywhere on the American continent. The refrain is usually interjectional and wholly meaningless; and the verses are often repeated without alteration, four or five times over. These were the simple resources of the native bards. They had one other. In every American language which I have examined for this purpose I have found the existence of a poetic dialect, of a form of speech markedly distinct from

that of ordinary life, a phraseology consecrated to the inspiration of the divine afflatus; as the noble old poet, Spenser, expressed it, 'a ladder of the gods.' In this, and in this alone, did the native poets pour out their wild chants. These, I say, were their simple resources. Do not look upon them with contempt. At no time has poetry felt that it could dispense with them"; and the author draws illustrations of the fact from Poe, Tennyson, and Clarence Mangan. A great many of these American songs "are wholly without intelligible meaning; both verse and refrain are merely interjectional; they are sound and fury, signifying nothing. Such are the war-songs of the Iroquois and many others which I could name. But in defense of these I would ask you to remember that they are *sung*, not written to be read, and they must be judged by the laws of vocal music. . . . These broken syllables, these choked utterances, these inarticulate cries are the emotional outbursts of sentiment and passion, the oldest, the most heartfelt, the most untutored language of human feeling, the spontaneous revelations of that common nature which makes the whole world kin."

The Salt Marsh of the Kavir.—Lieutenant H. B. Vaughan, who made a journey of 1,164 miles in eastern Persia, thus describes one of the most curious features of the country, the salt swamp of the Kavir: "As we quitted the defile, a sudden turn in the road presented to our astonished gaze what at first sight looked like a vast frozen sea, stretching away to the right as far as the eye could reach in one vast glistening expanse. A more careful examination proved it to be nothing more than salt formed into one immense sheet of dazzling brilliancy, while here and there upon its surface, pools of water, showing up in the most intense blue, were visible. Away to the north of it stood a distant row of low red hills. A peculiar haze, perhaps caused by evaporation, hangs over the whole scene, which, though softening the features of the distant hills, does not obliterate their details. This, which I now see before me, is the great salt swamp, to the presence of which the Dasht-i-Kavir owes its name. This swamp, lying at a low level in the center of the great desert, receives into its bed the drainage from an immense tract of territory. All the rivers flowing into it are more or less salt, and carry down to it annually a great volume of water. The fierce heat of the desert during the summer months causes a rapid evaporation, the result being that the salt constantly increases in proportion to the water, until at last the ground becomes caked with it. The Persians say that many years ago a sea rolled its waves over the whole of the depression where I am now traveling, and that it was navigated by ships which used to sail from Semnan to Kashan. My guide told me the following legend: 'One day, many years ago, long before the time of the Prophet, a holy man arrived at Kashan, took a boat, and ordered the man to sail him across to some point or other. The boatman, being of a suspicious turn of mind, insisted on payment of the fare before landing. This condition was accepted, but the amount offered was held insufficient, and a *pour boire* was demanded in addition. After a dispute the point was yielded, and the old man said nothing more until he reached the shore, when, taking up a handful of earth from the ground, he threw it into the sea, uttering the words, "Avaricious boatmen shall here ply their trade no more." The sea instantly disappeared, and in its place came the desert as it now stands; while the fish became turned into stones, the boatman who tried to swindle was struck with blindness, and the holy man went on his way rejoicing.' I suggested to my guide that this was rather a severe punishment for so small a fault, and that an earthquake or a severe storm which would have sent all the boatmen to the bottom of the sea might have been sufficient to meet all the requirements of the case. He said he didn't know about that; anyhow, this was the story as he had heard it recounted by his tribe, who had lived on the borders of the desert for ages."

The Leaves of the Tulip Tree.—In the examination of some young plants of the tulip tree (*Liriodendron tulipifera*), Mr. Theodor Holm observed that, though their germination did not present anything of particular interest, a peculiar feature appeared in their young foliage leaves. The two or three leaves showed a great similarity among

themselves, and at the same time differed from those of the older or full-grown tree. Induced by this discovery to examine the foliage of the mature tree, he found that there was a certain regularity of variation, depending upon the position of the different forms of leaves. It is well known that a great variation exists among the leaves of our recent *Liriodendron*, on the same tree, and even on the same branch. There are also great differences in the forms of the leaves of fossil species, which many palæobotanists, including Prof. Newberry, regard as being significant of specific distinctions. Mr. Holm believes, and undertakes to show in his paper, that the differences in the foliage between many of the extinct species of *Liriodendron* are not greater than between a series of leaves from a very young tree or from a branch of an older one of our recent species.

Navajo Burials.—Four methods of disposing of the dead are described by Dr. R. W. Shufeldt as practiced by the Navajo Indians. The commonest method is "cliff-burial," in which the body is removed from the lodge or *hogan* where the death took place, and is carried to a cañon, deposited in some of the rents or fissures in its sides, and is covered and walled in with pieces of rock and smaller stones. The body is often dressed in the clothes that the person may have possessed and valued during life. A second method is "brush-burial," and is resorted to in cases where illness has been long and no hope of recovery is entertained. The patient is carried to some secluded spot near the camp, surrounded with brush-cuttings as a protection against wild animals, and is either abandoned or fed from time to time by relatives until death comes. A third method is deposition in a grave; and the fourth is "tree-burial." This is extremely rare, so that only one case has come under the author's observation. The body was wrapped in a blanket and carried up into a large piñon tree to a horizontal limb about fifteen feet above the ground. At that point a rude platform had been constructed of dead and broken limbs, the whole so arranged as to support the body firmly in a horizontal position. The burials are all without ceremonies. The *hogan* is abandoned or burned immediately after the occurrence of a death within it, and is not in any event occupied by any of the tribe again. The Navajos have a notion that the devil long haunts the locality where death has taken place, and they all shun it. After a burial the party thoroughly wash themselves and make a complete change of clothing. They believe that an evil spirit is at the bottom of everything that has to do with death, and rarely speak of their dead for fear of offending him; and it has been said that one of these Indians will freeze to death rather than build a fire for himself out of the logs of a *hogan* in which one of their number has died. They are very jealous of any desecration of their dead; and Dr. Shufeldt was exposed to much danger in trying to get some of their skulls for scientific purposes.

Dances of the Passamaquoddy Indians.—In the snake dance of the Passamaquoddy Indians, as described by J. Walter Fewkes, in his paper on the folk lore of the tribe, the leader or singer begins by moving about the room in a stooping posture, shaking in his hand a rattle made of horn, beating the ground with one foot. He peers into every corner of the room, either seeking the snake or inciting the onlookers to take part, meanwhile singing the first part of the song. Then he goes to the middle of the room, and, calling out one after another of the auditors, seizes his hands. The two participants dance round the room together. Then another person grasps the hands of the first, and others join, until there is a continuous line of men and women, alternate members of the chain facing in opposite directions, and all grasping each other's hands. The chain then coils back and forth and round the room, and at last forms a closely pressed spiral, tightly coiled together, with the leader in the middle. At first the dancers have their bodies bent over in a stooping attitude, but, as the dance goes on and the excitement increases, they rise to an erect posture, especially as near the end they coil around the leader with the horn rattles, who is concealed from sight by the dancers. They call on the spectators to follow them, with loud calls mingled with the music; these cries now become louder and more boisterous, and the coil rapidly unwinds,

moving more and more quickly, until some one of the dancers, being unable to keep up, slips and falls; then the chain is broken, and all with loud shouts, often dripping with perspiration, return to their seats. The last part of this dance resembles a play among boys known as "snap the whip." This dance is performed at weddings and other festive occasions, and is said to derive its name from the sinuous course of the dancers. In the trade dance the participants, one or more in number, go to the wigwam of another person, and when near the entrance sing a song. The leader then enters, and, dancing about, sings a continuation of the song he sang at the door of the hut. He then points out some object in the room which he wants to buy, and offers a price for it. The owner is obliged to sell the object pointed out, or to barter something of equal value. Passamaquoddy Indians are believers in a power by which a song sung in one place can be heard in another many miles away. This power is thought to be due to *m'toulin*, or magic, which plays an important part in their belief. The folk stories of the Passamaquoddies are but little known to the boys and girls of the tribe. It is mostly from the old and middle-aged persons that these stories can be obtained. The author was told by one of these story-tellers that it was customary, when he was a boy, to reward them for collecting wood, or for performing other duties, with stories.

What constitutes a Filth Disease?—Summing up, in the Sanitarian, his observations in answer to the question, "What constitutes a filth disease?" Dr. S. W. Abbott concludes that a filth disease is one in relation to which filth in some form or other, either wet or dry, plays the part of an important factor only in its causation, but is not itself the direct cause; that it acts either as a favorable soil for the propagation of disease germs (other favorable conditions also existing), or as a suitable medium or vehicle for the transmission of the particular contagium from the sick to the well. The filth which promotes the spread of infectious diseases is specific filth, and the importance of removing all filth lies in the fact that thereby we are sure to remove the specific filth, or that which contains the germs of infectious disease. The point to be emphasized is, that when filth is removed it should be done with the principle in view that filth is a condition rather than a cause, that it is the soil for the culture and transmission of infection, and not the infection itself; and that, just so far as the principle of infection is deprived of its proper soil, so far is one of the most important conditions of its growth and propagation removed. In sanitation, careful watching and provision against the introduction of infectious disease, isolation of the sick, disinfection of houses, clothing, and other associated material are as essential as the removal of dirt.

The Special Talent to be cultivated.—The Workingman's School of the United Relief Works of the Society for Ethical Culture was founded in 1878, to be a free Kindergarten for the children of the poorer classes in the tenement-house district of the city. It has now between three hundred and four hundred pupils, with three grammar, three primary, and three Kindergarten classes, and owns a substantial five-story building for its class-rooms and shops. Besides the ordinary branches, its course of study embraces manual and art work, elementary natural science, gymnastics, and music, etc., and a Kindergarten normal department. After two years it was decided to attempt the development of the Kindergarten principle, "learning by doing," in such a way that it might become the basis for a complete course of study in a regular school covering the ages from the sixth to the fourteenth year. The school is not a trade school, nor is it adapted only to the needs of a particular class. It aims to give its pupils, be they rich or poor, an education calculated to bring all their faculties into harmonious play. The chief merit of the manual work is its educational value. Trades are not taught, but shopwork, modeling, needlework, etc., have been introduced as so many aids to cultivation and development of every kind. And thus, says the report, "we believe that one of the worst evils of conventional 'schooling' has been done away with. For our experience has clearly shown, that the standard of education, heretofore uni-

versally accepted, which makes the literary progress of a pupil the principal test of his mental capacity, is altogether false. Literary ability is a special talent, as much as is proficiency in music or in any of the fine arts. And as there are many persons who have not the slightest gift in these directions, so are there many who can not write a pleasing essay or letter, or appreciate the style of a great author; yet the unmusical man may be a clever and successful business man, and the non-literate man may become a great artist or develop genius in some other direction. In fact, many a man who in his boyhood found it difficult to adapt himself to the literary standard of the school has broken his way to fame and success by means of talents of which his pedantic teachers had not the faintest inkling. . . . In our school we have had and yet have pupils who seem to be still incapable of acquiring the art of composition or even the lesser grace of correct orthography. Some of these have been with us only a short time, and we are therefore not responsible for their deficiencies; but some have been pupils of the school from the Kindergarten up, and have received the same careful training as the others, yet they lag behind in language. Nevertheless, some of these non-literate pupils do admirable work in other branches. It has been noticed that in the case of these children proficiency in manual training and art work, and in natural history, usually go together. They exhibit the liveliest interest in these branches, and their inner life appears to be rich, while their faculty of expression is only a stammering. With such pupils the greatest patience must be exercised. After they have developed their peculiar bent, and are encouraged by their success in the manual branches, they gradually gain better control of tongue and pen."

Systematic Begging.—The business of begging is better organized in Paris than in American cities. A large association exists there, calling itself the Paris Syndicate of Professional Mendicants. The managing committee assigns posts to its members, protects them from competition, collects their receipts once or twice a day, and pays each one his proportion of the general profits once a week. The proper income of each post is accurately known, and any "embezzlement" is quickly detected and punished. A certain percentage of the receipts is retained for the general expenses of the syndicate and for a reserve fund. A lodging-house has been bought with this fund, and the remainder is invested in shares and bonds. There is no sick or burial fund—the sick are best able to excite charity, and when they become actually disabled there are the free hospitals; while the funerals of the poor are paid for by the state. Why should the professional mendicants waste their money on these things, when the tax-payers will provide them? The alleys in the Champs-Élysées are good posts for picturesque-looking old men. On a good day such should collect from thirty to forty francs each—six to eight dollars. One veteran used to get as his share of the division over seventeen dollars a week. He has now retired. The better class of mendicants look forward to saving enough to buy a cottage in the country, and living thereafter on an annuity, while the good-for-nothings spend their income in sottish debauchery. The Municipal Council, after an investigation, recently decided to tolerate the existence of the syndicate.

The Soaring Puzzle.—Marey, the author of Animal Mechanism, has recently published a book on The Flight of Birds, in which he gives an answer to the much-debated question as to how birds soar. Many persons have wondered at the power possessed by birds—especially the large birds of prey—of moving against a breeze without a flap of their wings. This has been regarded as like a log thrown into a river floating against the stream. Birds when soaring fly in circles or ellipses, which appear to observers below to lie in horizontal planes. But Bakounine discovered that these ellipses were inclined—the forward end being the lower. Taking this with the fact that a head-wind is a necessary condition, M. Marey concludes that each strong gust of wind, striking the bird's wings at an angle, raises it and wafts it backward, until the wind lessening somewhat permits the bird, by changing the slant of its wings slightly, to glide forward and downward with the force due to its elevated position. One side of an

ellipse is described as the bird is carried upward and backward, the other as it advances and descends. This theory makes the circling and soaring depend on variations in the force of the wind. But even when the breeze is steady birds seem to have the power of modifying its action by shifting the angle at which their wings are presented to it.

United States Division of Forestry.—Chief-of-division B. E. Fernow, in his report on Forestry, gives as the chief object of the establishment of the division the prospective danger to the future of wood-supplies arising from the heavy drains to which our virgin forests are subjected without any provision for recuperation or reforestation; the destructive nature of the measures now used for utilizing the natural forest areas; and the desirability, for the sake of climatic amelioration, of encouraging tree-growth on the treeless areas of the West and on regions of the East that have been made treeless. The capacity of yield of our present wooded area is estimated to be only half of the present computed consumption. In addition to the estimates we have reports from various manufacturers noticing the decline of supplies of particular kinds. It is thus obvious that the present rate of consumption is greatly in excess of the supply. The effect of unwise denudation upon soil, water-flow, and climatic conditions has been made a continued study, in the light of experiments and experiences in other countries rather than in our own. The results of Prof. Harrington's investigations into the literature of the subject are to be published. There are three methods open by which the Government can promote a change in present forest conditions: by placing its own timber holdings under rational treatment; by direct aid to those who would apply forestry principles in caring for the natural woodlands or in creating new forest areas; and by supplying information. The effort to promote timber-culture by offering free entries of land for planting one sixteenth of it in trees has not been successful. *Bona fide* settlers have failed, through unfavorable climatic conditions and ignorance of method and of plant material suited to the localities, to obtain the required stand of trees. A modification of the law, rather than its repeal, is suggested. Information has been supplied by the division in circulars, bulletins, addresses, papers, and informal talks to associations and meetings. Among the publications were circulars giving instructions for the growing of seedlings and for the treatment of seedlings in the nursery. The most important publication was one on the substitution of metal for wood in railroad ties. A check list of our forest trees is in preparation as a means in securing uniformity in nomenclature; and an examination is planned of our prominent timbers in regard to their technical and physical properties in order to ascertain, if possible, how far these properties depend upon the conditions under which the trees are grown, how far physical properties influence mechanical properties, and whether a simple method can not be devised of determining the quality of timber by gross examination of structure.

Forest in Hungary.—Of the 9,200,000 hectares (about 22,000,000 acres) of forest in Hungary, the Government owns about 1,500,000 hectares (or 3,500,000 acres), while the rest belongs to public bodies and private persons. The Government does not sell any part of its forests, but buys more each year. In some parts of the country, as in the eastern region of the Carpathians, woods are found of several thousand acres in extent, consisting for the most part of red beech. This is used for fire-wood, carriages, staves, and agricultural implements, and in the manufacture of bent wood. There are few fires, and they seldom permanently damage the woods. There are large resinous forests in Transylvania, but they are not very accessible; and there are also some in the district of Marmaros, in the northeast of the country.

International Selfishness. — The tidal wave of high tariffs that seems to be passing around the globe at the present time reveals an attitude of many peoples toward neighboring countries which is little better than that existing between communities during the most quarrelsome ages of history. The advocates of restrictive tariffs are not only zealous to increase sales for their own

people, but positively exult when they reduce those of foreigners. And, when one nation has injured another in this way, that other is now very likely to strike back by means of "retaliatory legislation." Americans and Europeans have sunk to the morality of the Chinese, who regard the sufferings of all but themselves with amusement and pride, and any one who talks of neighborliness and consideration for other nations is set down as too sentimental to meddle with practical affairs. Strange to say, the fact that foreign workmen are in want and misery has been urged as a reason for trying to injure them further. Even the socialists, who proclaim the brotherhood and equal rights of man, are very apt to limit these principles by geographical boundaries. But the further a pendulum swings from the upright position, the sooner its return may be expected. Hence it is quite likely that a new era is soon to dawn, in which humanity shall no longer be dominated by geography.

Dry Denudation.—Dry denudation is shown by Prof. Johannes Walther, in his book on Denudation in the Desert, to be a process of considerable geological importance. The author points out that no part of the African desert is absolutely rainless, and that, as the storms, though rare, are heavy, the mechanical effects of water are more marked than they would be in a region where precipitation was more uniform. But in a desert, where the absence of plants and of soil exposes the rock to the effects of atmospheric variations, changes of temperature are yet more potent in causing denudation. These changes, owing to the dryness of the air, are very great. The diurnal range may be 30° C., and the annual range as much as 70° C. By the constant expansion and contraction due to these variations, the rocks are split, and the results are more important in producing denudation than are chemical changes. Illustrations are given to show how rock-masses in the desert are destroyed by heat and cold, wind, and drifting sand. The surfaces of old walls are corroded; strata of different hardness in the face of a cliff are worn back unequally; masses of rock are isolated, and the blocks and pillars are carved into strange forms; denudation, in short, seems to proceed as actively in a desert as in a damp climate, and along very much the same lines. Isolated hills of tabular form are also characteristic of desert denudation. Such hills may be either on a large scale—outlines of an extensive plateau—or on a small one, like models, but a few feet high. In each case the cause is the same: a harder stratum at the top has preserved the softer material below. The author also describes the valleys of the desert, usually dry, and the cirques which, as was pointed out some years since by Mr. Jukes Browne, seem to occur in the deserts of Egypt even as in regions where ice may be supposed to have acted. "The description of the latter forms is important," writes T. G. B. in Nature, "since it indicates that there is not that necessary connection between glaciers and cirques which some geologists seem to have imagined."

The Teacher's True Power.—The extreme elaboration of system in school, says State Superintendent Sabin, of Iowa, gives us symmetry and uniformity, but it is at the expense of growth. It promotes smoothness, prevents friction, and furthers exactness of detail, but it crushes out all life, energy, freshness, and enthusiasm, and exalts itself to the chief place in the school. The child is forgotten in the worship and homage which is paid to the system. We sometimes speak of teaching the child to think. It is as natural for a child to think as it is for a tree to grow. It is not the part of the teacher to wake up the mind, but to avoid putting it to sleep. Give the child the same freedom to think and observe that the street Arab has in his games, only guide him with skill; take advantage of his curiosity and wonder; take advantage also of what he already knows, and do not attempt to teach over again what he has already learned, and he will startle you by his progress, and by the readiness with which he will profit under your instruction. There is no place in which the individuality of the teacher can so make itself felt, and in which the individuality of the child is so thoroughly alive, as in the primary room. The author does not object to the rigid examination in the case of young teachers; but, when that is once passed, the only conditions

imposed upon the teacher should be enthusiasm, life, growth. When these are absent, the teacher is dead. Knowledge, to be of any value to the teacher, must become a permanent, increasing, living force in his work and character. Knowledge which is non-productive is dead. Knowledge which is alive, which strengthens the memory, which guides the judgment, which enlightens the reason, which fortifies the will—this is the knowledge which, acting through his individuality, makes the teacher a power in the school.

Hand-marks.—M. Bertillon, of the Paris police, has devised a method of identification by photography of parts of human bodies. The hand being the part that is usually most affected by the occupation, series of photographs of hands have been taken, which may be compared with whole figures of the same workmen at their work. They show the effect upon the organ of friction from tools in use. From the hands of the navvy all the secondary lines disappear, and a peculiar callosity is developed at the spot rubbed by the spade-handle. The hands of tin-plate workers are covered with little crevasses produced by the acids employed. The hands of lace-makers are smooth, but they have blisters full of serum on the back and callosities on the front part of the shoulder, due to the friction of the straps of the loom. The thumb and the first joints of the index-finger of metal-workers show large blisters, while the left hand has scars made by the sharp fragments of steel.

Tea-culture.—According to a Society of Arts lecture by Richard Bannister, tea is derived from the cultivation of two species of tea plants, the Chinese and the Assamese. Hybrids of various degrees between these two form a great proportion of the plants usually grown. In the tea-garden the plant is kept down to from three to six feet in height; in a state of nature it reaches thirty or forty feet, with a stem one foot in diameter. The seed, which is inclosed in a hard, round shell, ripens about one year after the flower has faded. Planting is done either direct from the seed itself, or from nurseries where the young plants can be watched carefully and tended till they are strong enough to take their places in the plantation. Tea grows on almost all soils, but one that is light, friable, and rich is necessary for complete success. Close planting is recommended—viz., four feet apart—equivalent to 2,722 shrubs per acre. On steep slopes the Chinese variety may be planted closer—two feet by three and a half feet, or 6,223 plants per acre. A good deal of care must be devoted to pruning, with the object of keeping the shrub well spread and at a convenient height for picking. A tea plant is picked as the successive "flushes" occur. A flush is the throwing out of new shoots and leaves, the latter of which form the tea of commerce. The average flushing period is from seven to nine months, and the intervals between flushes vary from seven to fourteen days. The number of flushes ranges from eighteen, where no manure is used, to twenty-five in good soil. To a certain extent, the harder a tea plant is picked, the more it becomes stimulated to reproduce new shoots in the place of those lost. When the season is over, the tea bush is from three and a half to four feet in height and about five feet in diameter; pruning down, its height is reduced to two feet and its diameter to three feet. In this state it remains during hibernation. In the spring the buds at the base of the leaves develop into shoots, the buds of which develop themselves in the same way. The first shoot from the branch becomes the nucleus of subsequent flushes on that part of the bush, and is therefore carefully preserved. The youngest leaves give the best tea.

Making Incandescent Lamps.—An incandescent or glow lamp consists, according to Major-General Webber, from the manufacturing point of view, of the filament, the wire mount, or conductor, and the glass bulb. Inventors, seeking a highly refractory substance out of which to make the filaments, have all ended in using carbon of either a fibrous or an amorphous consistency. The form of the filament has been governed by the need to hold within a bulb of given size a carbon of a given length. The filament must have a uniform section, and that is most certainly obtained in those which are formed by squirting a viscous solution of cellulose into a precipitating solution. The filament material is wound upon blocks

of carbon and baked under great heat. Uniformity in resistance, securing equal consumption of current, of surface, and of incandescence, is also indispensable. To "flash" the filament for resistance, it is lowered into a glass chamber full of a hydrocarbon gas; it is heated by an electric current, and the carbon in the gas is deposited on the heated surface. In mounting the filaments, the important condition is to obtain a perfect electrical contact or joint between the metal and the carbon, and this is a very delicate point. The soldering is effected by electrically heating the joint in a vessel containing a liquid hydrocarbon surrounding, under such condition that the current shall pass through no part of the filament but the joint. Conditions opposite to those of an ordinary light are sought in inserting the filament in the bulb. Not rapid combustion but constant endurance of heating is wanted, and air is carefully removed by exhausting the bulb to one millionth of an atmosphere. In work, during the first two hundred hours of the life of the filament, the electrical resistance decreases slightly, and the brilliancy increases; for the next five hundred hours they are nearly stationary; after that, resistance increases and brilliancy decreases in a progressive ratio. The light is dimmed also by the gradual roughening of the surface of the filament and by the blackening of the glass from the deposition of carbon upon it.

Economical Plants of Australia.—With the exception of timbers, the economic vegetable products of Australia, as presented in Mr. Maiden's book on the Useful Plants of that country, are not of extraordinary importance. The northern regions, where the flora is re-enforced by representatives from the Malayan Archipelago and southern Asia, yield most of the plants possessing medicinal properties. The genus *Eucalyptus*, comprising more than one hundred and thirty species, yields excellent timber, kinos, and essential oils. *Eucalyptus gunnii* yields a sweetish sap which is converted by the settlers into excellent cider. This and manna, from two other species, are probably the only food products derived from eucalyptus trees. Oil from *Eucalyptus amygdalin* and *Eucalyptus globulus* is prepared in Australia and also in Algeria and California. In California it is available as a by-product in the manufacture of anti-calcaire preparations for boilers. The acacias of Australia, locally known as wattles, are hardly less useful than the gum trees. Immense numbers of them are destroyed for the sake of the bark used in tanning, and the leaves are greedily eaten by stock. By the operation of these two causes they are becoming scarce in some districts, and systematic attempts are now made to plant them on a large scale. Gum arabic of good quality is yielded by various species of acacia, but can not be profitably collected in the present condition of the labor market. Water is obtained by the natives for drinking, when springs fail, from the fleshy roots of a tree known botanically as *Hakea leucoptera* and from the stem of *Vitis hypoglauca*. Very few native Australian trees yield valuable fibers. The native mode of extracting fibers for their fishing-nets is by chewing with their teeth, and by this the teeth are "worn down to a dead level." The best fodder grass of Australia is the plant commonly known as "kangaroo grass."

Mistakes about Bearings.—Mistakes in orientation — sometimes of the most puzzling character—are usually the result of some incidental and temporary bewilderment, and may under peculiar circumstances overtake any one. Some instances have been cited by Sir Charles Warren in which they are chronic and may afflict even the best-informed persons. Erroneous conceptions formed by children as to distances and positions may grow up with them undetected till near maturity. Then, when the discovery is made, it is too late to apply any better remedy than to recognize the error and make allowance for it when possible. Cases are cited of a person whose ideas of certain parts of London were all inverted; of another, who placed Paris north of London; of thirty well-informed young men, "about eighteen were under the impression that, while the sun rises in the east, the stars rise in the west, from having learned that the sun has a proper motion among the stars; and the author believes that there are few educated men who have not grown up with some curious errors with reference to geographical facts, which have bothered them

all their lives, and which they have found it to be impossible to get rid of." This defect may account for some of the accidents that occur on railways and shipping.

Mexican Leather.—A report of the Belgian minister in Mexico shows that the export of leathers from that country is increasing, and on account of the favorable conditions for cattle-raising that exist there is likely to continue to advance. The trade is just now suffering from the careless and defective manner in which the hides are treated before shipment. The trade in alligator-skins is capable of great development, and promises all the elements of a lucrative industry, because alligators or caymans are abundant in all the lagoons and cost nothing. Nearly all the parts of this animal are used. The teeth are made up, in conjunction with gold, into ornaments and articles of jewelry, which find a ready sale; medical properties are ascribed to the oil, and it is highly appreciated for the manufacture of soap; but the most important part is the skin, which is very strong and handsomely marked, and is used for shoes, bags, and fancy articles. The skin of the iguana also has a value, but is less consistent than that of the cayman.

Mesopotamian Peoples.—The population of southern Mesopotamia is divided by Dr. B. Moritz into three classes. The Bedouins of the desert live in dwellings made of black goat's hair, possess "wonderfully large" herds of sheep and camels, and pursue cattle-lifting as a national sport. The second class—the dwellers along the rivers and canals—form the settled agricultural element, and, although enjoying the smallest area of country, are the most numerous class of the population. They live in reed huts, which are a cross between the tent of the nomads and the permanent house. At the time of the great inundations they frequently leave their abodes and seek other places of residence, where the conditions as regards the waters are more favorable. Many also proceed in the summer into the desert, and only return in the winter to attend to their fields. Rice, barley, and wheat are cultivated. Rotten fish forms also a chief article of food. The third class of the population are the inhabitants of the marshes, whose sole employment is the pasturing of their buffaloes. They are human amphibia, who, like their cattle, subsist on the lower parts of the reeds and rushes, and, as a rule, wear only a felt cap, stiff with dirt, on their heads; they are otherwise generally unclothed. They live in little rush huts which are frequently situated in an impenetrable morass. Their civilization is an indescribably low one.

Cultivation of Lemons in Sicily.—The ever-bearing lemon of Sicily, according to the consular reports, produces blossoms and lemons every month in the year. Lemons are known as true and bastard. The "true" lemon is produced by the April and May blossoms, the "bastard" by the irregular blooms of February, March, June, and July, which depend upon the rainfall or regular irrigation and the intensity of the heat. The true lemon requires nine months—from May to January—to reach maturity. A first harvest of fruit takes place in November, when the lemons are green-colored and not fully ripe. These are the most highly prized and can be kept in the warehouses till March, and sometimes May, when they are shipped. A second lot is harvested in December and January, but these must be shipped within three weeks. The fruit of the third harvest, which occurs in March and April, is shipped at once, and enjoys the benefit of the high spring prices. The bastard lemons may be known by the peculiarities in their size and appearance. They are hard, rich in acid, and seedless; will remain on the tree a year, and sell well in summer; and some will remain on the trees for eighteen months. Four times more lemons than oranges are raised in Sicily, and the cultivation is thirty per cent more profitable.

Parasites of Hospitals.—The Abuse of a Great Charity is the title of a paper by Dr. George M. Gould on the greed with which the advantages of gratuitous hospital practice are sought by outdoor patients who are able to pay for treatment but are willing to "get something for nothing." Among the baneful results of the abuse are counted the encouragement of pauperism, dependence, and deceit in a large class already too

prone to depend upon the state or charity instead of prudence or self-help; injury to the patient, from the hurried nature of the diagnosis which the physician is compelled to make, with the crowd pressing upon him; and to the physician, from the carelessness into which he is led; and degradation of the profession, by turning its practice into a sort of medical "free-lunch counter," by encouraging envy and subtle methods of advertising, and by the injustice of the system to younger and country practitioners. The author suggests a number of alternative remedies for the evil.

NOTES.

THE second report of the Committee of the American Association on the spelling and pronunciation of chemical terms, as presented to the Indianapolis meeting, includes all the rules and categories of words given in the report to the Toronto meeting, but with the pronunciations of words as enumerated in that report usually omitted, unless they have evoked opinions at variance with the recommendations of the committee from more than one correspondent. As the list is limited, brief summaries of the reasons for divergent views are frequently appended, with indications of the authorities referred to. It is desirable that the next report of the committee should be thoroughly representative. The co-operation of all American chemists is therefore sought, and every chemist is requested to examine the list and note all variations from the spelling recommended that seem to him desirable.

PROF. H. W. CONN, in a paper on the Fermentations of Milk and their Prevention, notices, as an advantage arising from pasteurization that adds greatly to its value, that nearly all the pathogenic disease germs which are likely to occur in milk are killed by it. It is recognized that some of our dangerous epidemics are transmitted from house to house by means of milk, which furnishes a good medium for their growth. If pasteurization is sufficient to kill the disease-germs, and if at the same time it delays the souring from twenty to forty hours, and if the milk thus treated retains the taste of fresh milk, and permits the cream to rise on it in the natural way, it is plain that it is a process highly to be recommended. It consists in heating the milk to a temperature of about 155°, or a little higher, and then rapidly cooling it.

A TELEPHONE line has been laid between London and Paris, and is working successfully.

ACCORDING to a paragraph in *La Nature*, the people of Brazil have domesticated a species of snake for the purpose of keeping down rats. It is the *giboia*, a kind of boa, which attains about thirteen feet in length, but is no thicker than one's arm. These snakes are sold for about a dollar apiece in the markets of Rio Janeiro, Pernambuco, and Bahia, They are inoffensive and graceful, and pass the day asleep. At night they begin their hunt, penetrating everywhere, even between the ceilings and the floors, and doing extensive execution on vermin. They learn to know their home, so that, when carried off, they are able to find their way back. They are said to be fixed in every house in the regions infested by rats, and to have especial individual qualities which the proprietor can boast of when he wishes to sell or let his place.

THE Société d'Encouragement pour l'Industrie National, of Paris, France, has awarded Mr. Henry Marion Howe a prize of twenty-five hundred francs for his magnificent work on the metallurgy of steel. The first edition of this work was exhausted within a few weeks after its appearance. The second edition, just published, contains a few revisions by the author, and additions describing some recent advances in the processes of making steel directly from the ore. The work is published by the Scientific Publishing Company, New York.

EXPERIMENTS recently made in a Prussian battalion have shown that dogs may be trained to hunt up the wounded after a battle, and call the attendants to take care of them. In training the dogs, certain soldiers pretend to be wounded, and lie upon the ground as they would do if that were the case. The dogs are sent out to hunt them; and when a dog finds a prostrate man he stands by him and barks till some of the ambulance-men come up. Every company of the battalion has twelve dogs trained in this way. Shepherds' dogs and wolf-dogs seem best adapted for this purpose, while very little can be made out of hunting-dogs.

THE French Academy of Sciences has received a legacy of one hundred thousand francs from the late M. Cahours, the interest of which is to be distributed every year by way of encouragement to any young men who have made themselves known by some interesting works, and more particularly by chemical researches. A preference is expressed by the testator for young men without fortune not having salaried offices, and who, from the want of a sufficient income, would find themselves without the possibility of following up their researches. He also recommends that the money be given to the same young men doing satisfactory work, for several years—to cease, however, when they obtain sufficiently remunerative positions to make the aid unnecessary.

M. CHARLES BRONGNIART has communicated to the French Academy some observations on the peregrine locusts in Algeria, which passed continuously for several days over Mustapha and Algiers, and were so thick that one could not go into the street without being hit by them. To deposit her eggs, the female bores into the hardest ground, even in the trodden roads, sometimes trying the soil first, to the depth of from five to eight centimetres. She lines the bottom of the hole with a light whitish substance like beaten egg, and covers her eggs, after she has deposited them, with the same substance. In some places an average of thirty-five deposits per square decimetre was counted, each containing eighty or ninety eggs. The insects succumb immediately after laying, and shortly die; and the bodies lie scattered around at the rate of thirty per square metre, food for birds and predatory insects. The ground where the eggs have been deposited is easily recognizable from a distance.

A COLLECTION of Eskimo works of art, made by Assistant Superintendent Edwards of the cryolite mines at Arsuk Fiord, Greenland, is described by John R. Spears, in Nature. It includes candlesticks, cigar-holders, ash-receivers, anchors, paper-weights, etc., made of green-stone. The articles were all made to sell to the Danish rulers, for the Eskimo themselves have no use for ornamental art; but they show considerable skill in sculpture.

THE Andaman Islands, constituting a small isolated territory, furnish rare opportunities for the study of the introduction and growth of new plants. They have been under scientific observation since 1858. Dr. Prain, of Silpur, records that in 1866, when there were six hundred known indigenous species, fifteen intentionally introduced plants and "sixty-one weeds of cultivation" had become established as an integral portion of the flora, and that by 1890 twenty-three more of the first class and fifty-six more of the second kind had been added, while four of the naturalized plants noted in 1866 had disappeared. A common Indian butterfly has made its appearance since the plant on which its larva feeds became naturalized.

A COMMITTEE of London municipal officials has been ordered to report upon the advisability of erecting a crematorium in the cemetery at Ilford. Mr. Malthouse, one of the sanitary officials of the city, has called attention to the fact that 91,243 bodies were buried last year in the London cemeteries, and that in many places they lay fourteen deep. High medical authority had declared already that the state of the cemeteries demanded the intervention of the Government. Cremation, he said, was the only practical alternative of burial, and would soon be adopted, if the costs were reduced, as the prejudice against it was disappearing very rapidly.

AN experiment has been made by Dr. Pringsheim, of Berlin, to determine the position of the accent in French words by a physical method. A phonautograph was used, into which a number of Frenchmen spoke, and the record was afterward measured by means of a tuning-fork curve running parallel to it. It was possible thus to determine the duration, pitch, and intensity of each syllable. As the results related to French words only, it may merely be mentioned here that the shortest syllable, *é*, in été, with rather a slow pronunciation, consisted of twenty-two vibrations; yet the ear, besides hearing the tone, is capable of detecting fine shades and differences in the mode of pronunciation.

OBITUARY NOTES.

DR. RICHARD SCHOMBURGK, Director of the Botanic Gardens at Adelaide, South Australia, has recently died there. He was associated with his brother, the late Sir Robert Schomburgk, in the Boundary Demarkation of British Guiana in 1840; some years later settled in South Australia as a farmer and wine-grower; became Director of the Botanic Garden in 1866; founded the Museum of Economic Botany, and was an eminent horticulturist. He was author of a book in German of travels in British Guiana, in which were embodied a flora and fauna of the country; of Botanical Reminiscences of British Guiana; and of papers on the agricultural and horticultural capabilities of South Australia and the Botanic Garden.

THE death is announced of Prof. Weber, of Göttingen, the celebrated physicist. He was born in 1802. His first scientific publication was the Theory of Modulations (Leipsic, 1825). Being a liberal in politics, he was turned out of his professorship by King Ernest of Saxony. He soon afterward began to devote himself to magnetism, gave a new impulse to the study of electricity in Germany, and became one of the first authorities on the subject in Europe. He was restored to his chair at Göttingen in 1849, and resided there for the rest of his life.

PROF. CARL WILHELM VON NAGELLI, an eminent German botanist, died at Munich, May 10th, in the seventy-fourth year of his age.

SIR JOHN HAWKSHAW, an eminent English engineer, died in London, June 2d, in his eighty-first year. He was President of the Institution of Civil Engineers in 1862–1863, and of the British Association at its Bristol meeting in 1875. His greatest engineering feat was the construction of the Severn Tunnel.